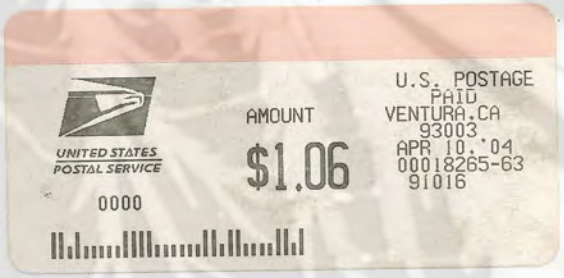
Unpublished letters to the Electrotherapy Museum

The following letters were never meant to be published. There is some moral divide in such a situation as to what to do with correspondences of friends that have moved on. Oftentimes in cases where passions run high on various subjects, harsh words can be said criticizing fellow members of the field of research. It is not the intention of these letters to put anyone in a bad light. We are all, as it were, part of this history. We all tried our best to collaborate with each other as sincerely as possible, even during times when our lives were falling apart or even out from under us. These correspondences are simply fragments of conversations that still remain. When most of my treasured colleagues moved on, their belongings and letters were dispersed, many of which were disposed of. (This includes letters within the Tesla family.) Words can never express the frustration I feel for such unfortunate situations. I have endless respect for each one of these people. I was privileged to call them my colleagues. I was privileged to call them my friends. And we were, as a team, a small number of historians defending the truth, solving mysteries together, saving history at any cost, and doing our best to discourage the myths and pseudoscience that prevailed time and time again against everything we believed in. What can I say? Fiction sells. And yet sadly, Nikola Tesla was one man in history whose story needed no embellishments.

I miss you guys.

Jeff Behary 08. November 2019

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Betty C. Lientz
697 Sapphire Ave.
Ventura, CA 93004-4019



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Bill Wysock
2527 Treelane Avenue
Monrovia, California 91016

Please Do Not Fold!

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Betty C. Lientz
697 Sapphire Avenue
Ventura, California 93004

(805) 647-3165

April 10, 2004

Bill Wysock
2527 Treelane Avenue
Monrovia, California 91016

Dear Bill:

I am so glad Jim Hardesty suggested that I call regarding my limited knowledge about Frederick Finch Strong, M.D. He sent me the book "High-Frequency Currents" by Dr. Strong. Actually, I had no idea that Dr. Strong's early efforts included this endeavor so I was totally surprised.

As you can see from the enclosed correspondence, the Lientz Family became acquainted with Dr. Strong through Earl Hill Wilson and Refined Sulphur, which was used in treating his injury from Roentgen x-ray. Actually, my only familiarity with Dr. Strong was through Refined Sulphur.

I have no idea when he died but I am much younger than he. I am 81 years old. The story as to how the Lientz Family became associated with Earl revolves around Refined Sulphur and an injury to my left eye on July 15, 1935. The story is long so I do not want to burden you with it, unless you would like it just for background information. Refined Sulphur in the form developed by Earl has the ability of helping the body heal itself of many diverse diseases and do it safely.

It would be interesting to learn of your work at the Griffith Park Observatory and of the person about whom you spoke during our conversation. If I recall correctly that person has background in the medical field.

Very cordially yours



Betty C. Lientz

BCL:lb
Enc.

IAN MACDONALD, M. D.
2007 WILSHIRE BOULEVARD
LOS ANGELES 5, CALIFORNIA
FAIRFAX 2211

December 14, 1943.

Dr. Ralph R. Mellon
6055 Bunker Hill Street
Pittsburgh, Pennsylvania.

Dear Doctor Mellon:

It has been suggested that I outline for you some personal experiences I have had with the clinical use of hydrosulphosol preparations. My experience with this agent has been limited to its use in two conditions; the treatment of late sequelae in damage to the skin from irradiation, and in the management of post-operative cases in which the actual cautery has been used for cancer. Both of these conditions may be regarded as 'burns

An example of the first condition mentioned, of extraordinary interest, was provided by a patient suffering from extensive, intractable ulceration involving about one-third of a leg with exposure of the tendo Achilles in its base, and in which amputation was being considered. The use of hydrosulphosol saw the first improvement after months of other treatment, the area became entirely healed and has remained so for over a year. I have already provided you with microscopic sections from this patient.

The use of hydrosulphosol solution and ointment in post-cautery wounds seems to hasten the separation of sloughing tissue, with more rapid establishment of healthy granulation tissue and diminution of the exudative process. I am unable to offer any opinion as to whether the time required for complete healing is decreased.

With best regards,

Sincerely yours,

Ian Macdonald

Ian Macdonald, M.D.

IM:m

CHARLES W. HYDE, M.D.
1801 Eye Street, N.W.
Washington, 6, D. C.

March 31, 1947

Dr. Archie Edward Cruthirds,
Phoenix, Arizona

Dear Doctor Cruthirds:

On February 11 you were kind enough to write me at length and advise how best I could use Hydrosulphosol in the treatment of X-ray burns on my hands. These burns were received about twenty years ago as the result of X-ray therapy for ringworm. I had one small graft six years ago which was successful; another a year ago in the same place which was unsuccessful. Healing failed to take place, the area spread and a diagnosis of secondary epithelioma was made, and I lost three fingers on my right hand. The skin on both my hands had steadily grown worse so that I had an ulcer on the remaining finger of the right hand and five on the fingers and palm of the left hand varying from the size of a dime to the size of a pea.

After receiving your letter I was greatly encouraged and followed your suggestions. After reading your first article I started using the ointment, which I thought was somewhat irritating. After your letter I began treatment with warm soaks, usually of about twenty minutes' duration and 1-40 strength, four times a day. Also, I applied the ointment over night with a retention bandage. During all this time I was able to do a certain amount of work. I also took about twelve minims of the solution four times daily.

At this time the ulcers are all entirely healed and the remaining skin on my hands is in much better shape than before I began treatment. I feel that this treatment has been so efficacious that with reasonable effort on my part I should have no further trouble.

I cannot tell you, of course, which treatment is the best to use, but I do believe all three methods should be employed.

It is unnecessary for me to tell you, Dr. Cruthirds, of how much assistance you have been to me, and how very fine it was for you to take so much time personally to assist me.

Assuring you of my great appreciation, and with best wishes, I remain,

Yours very sincerely,

Charles W. Hyde, M. D.

THE WESTERN PENNSYLVANIA HOSPITAL
INSTITUTE OF PATHOLOGY
PITTSBURGH, PENN'A

April 17, 1944

Mr. Oliver K. Lientz
1006 West Sixth Street
Los Angeles, California

Dear Mr. Lientz:

In response to your letter of March 31st can say that I have clinical reports from several physicians who have used Hydrosulphosol on burn cases. Abstracts and summaries from these follow.

The most complete are the reports of Dr. W. F. Pierce who has a series of 65 cases of which 44 were treated in the hospital and 21 were ambulatory. Of the 44 hospitalized cases, 8 had burns of third degree, 19 had both third and second degree burns, and 7 had second degree burns.

Dr. Pierce states it as his opinion that there is a general balance in favor of the cases treated by Hydrosulphosol as against another series of cases in which other methods were employed. More specifically, he notes an absence of evidence of clinical infection, with the exception of a single case. Moreover, there is no indication of toxicity by Hydrosulphosol because its use in "shock" cases requiring plasma had no restraining effect on the prompt response to this agent.

By way of support for the wound-healing possibilities of Hydrosulphosol, the most suggestive is the very full report (including periodical biopsy slides) of a case of delayed X-ray burn by Dr. Ian McDonald. Widespread ulceration had finally supervened 15 years after low voltage X-ray treatments in a case and had led to the development of multiple telangiectoses, extending on both sides from Poupart's ligament to the heels. The biopsy showed the characteristic lesions of the X-ray, both in the obliterative endarteritis in the floor of the ulcer and the pre-cancerous changes in the epithelium.

The fact that the largest ulcer whose area was 48 sq.cm., continued to spread under a variety of accepted treatments whose duration covered more than a year; and, that after three weeks of Hydrosulphosol one-half of its area became covered with new epithelium and complete healing eventually took place, is exceedingly suggestive. In addition, the lesion was badly infected with Staphylococcus aureus and B. pyocaneus.

THE WESTERN PENNSYLVANIA HOSPITAL
INSTITUTE OF PATHOLOGY
PITTSBURGH, PENN'A

April 17, 1944

Reinforcing this unusual case were two other's reported to me by Dr. Logan Leven of the University of Minnesota Hospitals. These were very extensive third degree burns which failed to heal or to permit grafts to grow, due to an infection with Staphylococcus aureus, which was resistant both to penicillin and sulfathiazole. Both cases healed completely under treatment with Hydrosulphosol.

That this effect resulted from stimulation of the tissues is suggested by the fact that the action of Hydrosulphosol on Staphylococcus aureus in vitro is much too weak to permit one to think that the primary action here was bacteriostatic. It is noteworthy that Meleny, in his comprehensive report of the influence of the sulfonamides against staphylococcus and pyocyaneus infections showed these drugs to be unsatisfactory in combating them.

In addition I have summary reports of Dr. Kearney Sauer of Los Angeles and of Dr. Easley of Torrance, California. Dr. Sauer states that he treated a number of cases with both the solution and ointment form of Hydrosulphosol. He gives it as his opinion that the advantages are as follows: 1) Forms a flexible coating over the lesion, which is not of a "tanning" nature, but which is sufficiently flexible to permit motion of affected parts and thus help to prevent contractures; 2) the period of granulation is shorter and scarring is less.

Dr. Easley treated about 50 cases with Hydrosulphosol and gives his opinion as follows: Quicker healing and less scarring occur and clinical infection, when present, is cleared up. He noted particularly good results in flash burns of the eyes, and on burns caused by acids. Virtually no scarring occurred.

In my opinion these observations are sufficiently suggestive to justify the critical study of larger numbers of infected cases with a view to seeing whether such important studies as those reported to me by Dr. Logan Leven can be confirmed.

Trusting that this is the type of information you desired, I am

Sincerely yours,

Ralph R. Mellon

Ralph R. Mellon, M. D.

SPECIAL TECHNIQUE FOR THE
SUCCESSFUL TREATMENT OF
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"(STREP THROAT")
COMMON "COLDS"
INFLUENZA ("FLU")
SINUS INFECTIONS
ACNE; IMPETIGO
BRONCHITIS, ETC.

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April 22, 1946

Dr. A. E. Cruthirds:
Phoenix, Arizona.

My dear Doctor:

Learning of your successful work on "X Ray Burns" by the use of WILSONS HYDROSULPHOSOL, I am writing this letter detailing my own experience in successfully treating myself of a spreading Epithelioma of the left wrist, - a remote result of cumulative X Ray exposures received nearly fifty years ago.

I have not had the pleasure of knowing you personally so am enclosing copy of my Biography as you will find it in "WHO'S WHO IN AMERICA", and in "WHO'S WHO AMONG PHYSICIANS AND SURGEONS" - this will give you my medical and scientific background, and will serve in lieu of an introduction.

While this letter is personal to you I hereby authorize you to use it in any way you wish, as it contains facts which should be known to the Medical Profession.

From my own experience I can emphatically corroborate your successful use of WILSON'S HYDROSULPHOSOL in the cure of skin lesions of a malignant or non-malignant nature caused by over-treatment by X Ray or Radium.

(Report by F.F.Strong,M.D.)

In the year 1900 I attended a meeting of the A.M.A. at Johns Hopkins Medical School in Baltimore, where I read a paper before the "ROENTGEN SOCIETY OF AMERICA" -which was then a department of the A.M.A. (let me say parenthetically) that I was an active member of the A.M.A. from 1898 to 1922. : I dropped my membership at the latter time expecting to devote myself to Lecture and Research work. When I took my California license and began practice here as a Physician and Surgeon, I did not resume my A.M.A. membership (for purely personal reasons) I explain this because I have been censured by A.M.A. members. For this reason I had printed the WHO'S WHO data enclosed. I write this in order that my right to speak as an authority on Radiology be not questioned. Please pardon this necessary explanation.

To return to my report-

At the Roentgen Soc. Meeting I was appalled to see dozens of leading Radiologists with bandaged left arms, - some with amputations at wrist or elbow. I found that all these men had been in the habit of repeatedly holding their left hands between the Ray Tube and the Fluoroscope, in order to allow patients and others to "see the bones" by the -(then) - recently discovered Roentgen "X Ray".

Returning to Boston I began the construction of my first Tesla-High-Frequency Apparatus, intending it for X Ray purposes. I soon found that these currents possessed remarkable vitalizing powers, and later published by book "HIGH-FREQUENCY CURRENTS" (Rebman Co.N.Y and London, 1908)

If you can find this book in any old medical library you will find the subject of X Ray overexposure discussed in detail.

While I suffered no ill effects from my own Fluoroscopic carelessness in the early days of my work with X Rays, I have the best of reasons for knowing that the left hand and wrist were permanently (as I thought) devitalized. The first evidence of this was a Dupeytren's contraction of the left palmar tendons, which began over ten years or more ago. This was over thirty years since I stopped exposing my hand to X Rays. About seven years ago the skin of the left wrist began to break down and show evidence of X Ray- induced malignancy. This slowly increased during the following year and only began to heal after I begun the use of HYDROSULPHOSOL locally on the affected part, as well as in my bath water. After a few months regenerative changes began and within six months the lesions entirely disappeared and today the affected hand is normal except the contracted palmar tendons, and even these are better (I do not believe the Dupeytrens contraction is due to the X Ray, inasmuch as the right palmar tendons are still slightly affected)

My hands are otherwise normal: I can play the harp and still make a fairly good Golf score.

As I believe my case report to be of great importance I have been, prehaps, somewhat prolix in seemingly non-essential details, but I have thought the latter necessary.

THE WHOLE PURPOSE OF THIS LETTER IS TO POINT OUT THE REVITALIZATING POWER OF WILSON'S HYDROSULPHOSOL, ESPECIALLY IN CURE OF LESIONS OF THE SKIN RESULTING FROM OVERTREATMENT BY X RAYS OR RADIUM. I FEEL THAT I OWE MY LIFE TO THE CURATIVE AND VITALIZING POWER OF HYDROSULPHOSOL - THE PRODUCT OF THE RESEARCH AND DISCOVERY OF MY DEAR FRIEND

THE LATE MAJOR EARL HILL WILSON.

SIGNED

Frederick Finch Strong M.D

SPECIAL TECHNIQUE FOR THE
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April 29, 1943

Ralph R. Mellon, M.D., Director,
Institute of Pathology,
The Western Pennsylvania Hospital,
Pittsburgh, Penn'a.

Dear Dr. Mellon:

Referring to the case of Mr. Fiske O'Hara who was a patient of mine, I wish to advise that I treated Mr. O'Hara for diabetic gangrene some three years ago. Mr. O'Hara, who is now residing at 1326 North La Brea Avenue, Hollywood, California, was 62 years of age when I treated him for the difficulty referred to.

When I first saw Mr. O'Hara his left foot was badly infected with diabetic gangrenous lesions that were exuding a blue-black ichor. The discoloration extended upward to a point just above the knee and the ankle and foot were considerably swollen. There was evidence of a similar condition developing in the right foot.

While I had been acquainted with Hydrosulphosol and its action in certain other conditions, I had not previously used this sulfhydryl solution in a situation as far advanced or as serious as Mr. O'Hara's case presented. But under the conditions and knowing that Hydrosulphosol therapy was entirely safe I felt its trial to be well indicated. The final results, I think, may be appraised properly as most astounding.

The course of treatment followed by Mr. O'Hara consisted of the following: Soaking the foot twice daily for 30 minutes each time in approximately a 1:250 dilution of Hydrosulphosol in warm water (30 cc in 2 gallons). Between foot baths 2 to 3 wet compresses, saturated with full strength Hydrosulphosol solution, were applied on the instep and sole of the foot daily.

After institution of Hydrosulphosol therapy no other treatment was prescribed so that I feel safe in saying that the results that followed can be clearly credited to this sulfhydryl solution. Particularly does this appear justified when it is considered that other treatment designed to alleviate the condition had proven ineffective for a period of more than three months preceding institution of Hydrosulphosol therapy. As a matter of fact the condition of the leg had become steadily worse and Mr. O'Hara was facing the possibility of having to undergo amputation.

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The response to the foregoing uses of Hydrosulphosol became manifest unexpectedly in a matter of days, with a quick decrease in pain and relief from uncomfortable restrictions imposed by such a condition. One change noted very early was the disappearance of an odor that was objectionable, to say the least.

Within a matter of three weeks there was a marked decrease in the swelling and the patient was able to begin to resume normal activities. During the next few weeks the improvement was so rapid that by the end of three months it could be said that the entire trend had been reversed and healing was practically complete.

When Hydrosulphosol therapy was initiated there was a discharge of blue-black ichor from four seperate openings in the sole of the left foot and a perforating type of ulcer on the top of the foot posteriorly from approximately the middle toe. When healing was complete all of these openings had filled in to a normal level with no contracture and only mild scarring.

The comparatively minor condition noted in the right foot yielded rather quickly to the same treatment with Hydrosulphosol and Mr. O'Hara has continued to enjoy good health.

If you agree that the results observed in this case deserve presentation, which certainly would concur with my opinion and experience based on more than 40 years of active medical practice, you may use the information contained in this letter in any way you see fit.

I regret I cannot give you more detailed data but as you have had opportunity to personally verify the facts from Mr. O'Hara and examine the foot and leg in question, I feel you can evaluate this case with full confidence as to its representing an outstanding achievement in Medical Practice.

In closing I wish to express my pleasure in having had the opportunity to study your published report on Hydrosulphosol. Also I am happy to report this case to you, not only because of the satisfactory outcome of such a case as Mr. O'Hara's which previously has always presented a discouraging prognosis but also because, in my opinion, this product is deserving of the widest possible adoption by the Medical Profession.

Cordially yours,

Frederick Finch Strong M.D.

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PANEL PROCEEDINGS SERIES

RADIATION DAMAGE AND SULPHYDRYL COMPOUNDS

PROCEEDINGS OF A PANEL
ON RADIATION DAMAGE TO THE BIOLOGICAL
MOLECULAR INFORMATION SYSTEM
WITH SPECIAL REGARD TO THE ROLE OF SH-GROUPS
ORGANIZED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY
AND HELD IN VIENNA,
21-25 OCTOBER 1968

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 1969

FOREWORD

For a very long time it has been known that sulphydryl groups are an important structural part of protein molecules and play a substantial role in their functions. With the recognition that the SH containing enzymes are very sensitive to radiation and that the presence of cystein can prevent radiation damage, the small molecule SH substances have become the most promising source of radioprotective agents found over the last twenty years.

Much has been published on radioprotective agents despite their short history. Almost all radiobiologists have done experimental work on radiation protection at some stage in their scientific careers, hopeful that it might be possible to prevent the damaging effect of radiation on living beings simply by administering a radioprotector. Many new protective compounds were discovered, but as the ideal protector (high-protection, low-toxicity, long period of effective protection, etc.) did not materialize, only a hard core of researchers have continued to concentrate on radioprotective drugs.

In the meantime a new field of life sciences, molecular biology, has come to the fore, and substantial contributions have been made in this subject by radiobiologists. Remarkable progress has been made in our understanding of such problems as the genetic role of deoxyribonucleic acid, the transfer of information through the chain of ribonucleic acids to proteins, and the regulation processes at the molecular level.

These achievements, together with the recent discoveries on the repair and recovery of radiation damage to molecules and cells, offer new perspectives and concepts for the study of the mechanism of action of radioprotective compounds. The radiation damage to the important biological macromolecules and the mechanism of the radioprotective effect represent fundamental problems in contemporary radiobiology. Their study can contribute to the better use of radiation in various practical applications, such as the radiation treatment of tumours, and is of great importance to the field of radiation health and safety.

In October 1968, the International Atomic Energy Agency convened a panel on Radiation Damage to the Biological Molecular Information System with Special Regard to the Role of SH Groups. The papers considered and the conclusions arrived at by the Panel are presented in this volume.

CONCLUSIONS

The participants to the Panel felt that the scientific contribution of the papers presented and the lively and valuable discussion which followed clearly justified the holding of the Panel. The meeting provided a good opportunity for participants to clarify the aims of their future work and provided many stimulating ideas.

The spectacular progress made in molecular biology in the last years has provided a firm foundation for further research in radiation biology. The new findings continue to emphasize the extremely important role of SH groups in the function of biological macromolecules, and give some evidence for their possible participation in the control and regulatory processes in the living systems. SH and SS compounds represent one of the most important classes of radioprotective agents so far discovered.

There are many mechanisms which could play a rôle in the protection of the cell against radiation damage and, at the present time, none of these mechanisms can with certainty be excluded as providing no contribution to radioprotection. The situation is even more complicated in higher organisms, involving as it does intracellular, hormonal and nervous interrelationships. Investigations into the mechanisms of protective action must be continued at all levels, from the molecular to that of whole organisms. In particular, detailed study is needed on the nature and intracellular level and localization of the SH compounds before and at various times after administration of the radioprotector. It also seems essential for research into chemical radioprotection to take advantage of the great progress made in understanding the repair and recovery processes. Protection against low doses or continuous exposures to low levels of radiation needs further investigation.

In general the SH compounds used as radioprotectors in mammals are toxic to a greater or lesser extent at the levels required to provide a measure of protection. The Panel Members believe, however, that toxicity will not continue to be the limiting factor. Research on new compounds indicates that it may be possible to prepare compounds of lower toxicity; of special interest are compounds which may be metabolized in vivo to liberate the active protector.

There is no reason to believe that the compounds known at present are the only ones of interest. Recent observations show that new classes of chemical radioprotectors may exist and the search for new compounds should be encouraged. Most of the radioprotectors tested provide protection for only a short time, and these are therefore of little use in cases of protracted or chronic irradiation. Special efforts should be devoted to the search for long-acting radioprotectors.

Experimental data have shown that mixtures of SH protectors and combinations of sulphur-containing and non-sulphur-containing protective compounds with different mechanisms of action are more effective, and may be less toxic, than when one of the substances is given alone. A much better understanding is needed on the use of such mixtures. Detailed studies of the long-term toxicological, mutagenic and teratogenetic effects of SH compounds and other radioprotectors in mammals should be undertaken.

Generally speaking post-irradiation death of cells and animals has been taken as the endpoint in most experiments on radioprotection. It is important to study the protective action against other effects of irradiation in isolated cells and in different cell populations within multicellular organisms.

There are good reasons for believing that normal tissues can be selectively protected by SH compounds, using systemic administration of a radioprotector in the radiotherapy of tumours. At present this principle cannot be put to the test because of the toxicity of the existing compounds. The Panel Members feel, however, that the existing protectors can already be used for local application in cases where localized protection of normal tissue is useful during radiotherapy.

As far as the protective action of SH and other compounds against the late effects of radiation is concerned, present knowledge is still very sparse. There are some indications that SH compounds can decrease the radiation damage to embryos, and reduce post-irradiation vascular damage. Protective substances have been reported to be largely ineffective in preventing radiation-induced cataract and life-span shortening. The available data do not permit of an evaluation as to whether treatment with protective agents modifies the genetic and carcinogenic actions of ionizing radiations significantly.

All past achievements, as well as the hopes for future progress depend heavily on basic work in molecular, cellular and animal biology and physiology. It has become clear that topics which seemed very far removed from fields of practical applications of nuclear energy are in fact vital for the further developments in these areas. The Panel strongly recommends that the International Atomic Energy Agency should prolong and amplify its efforts to further stimulate both basic and applied radiobiological research.

Further study of radiation effects and radioprotection might stimulate new work in the very important fields of biological dosimetry, and on biochemical and biological indicators of radiation damage.

SUMMARY AND RECOMMENDATIONS

1. In view of the recent developments in the nuclear sciences, in their practical applications and in the rapid increase in the uses of nuclear technology, it was unanimously agreed that a renewed effort to stimulate research in radiobiology is essential to ensure safe use of nuclear energy with respect to man and other living organisms.

2. Basic information gained from studies of radiation protectors is as important for health physics and radiotherapy as it is for radiobiology.

3. In this context (2), data on chemical protectors were reviewed and their actions discussed for the various levels of organization and function of living units:

(a) macromolecules (nucleic acids, proteins)
(b) viruses and micro-organisms
(c) cells
(d) whole organisms

4. Despite the many experiments, using various techniques, on many living and non-living systems, no generalized statements on the modes of action of radioprotectors can be made; several promising hypotheses are currently being tested.

5. It is recommended that there should be an intensification of study on:

(a) The biochemical and pharmacological effects of radioprotectors and radiosensitizers;
(b) The possibility of protecting mammals and men against the late effects of ionizing radiation (carcinogenesis, fibrosis, genetic and developmental disturbance);
(c) The influence of radioprotectors on the repair and recovery mechanisms active in critical tissues like bone marrow, intestinal epithelium, lymphoid organs, gonads, endocrine systems;
(d) The possibility, clearly indicated by recent observations, of developing other types of sulphur-containing radioprotectors and also non-sulphur-containing protectors;
(e) The usefulness of applying mixtures of radioprotectors.

6. Progress in fundamental research and in the practical use of chemicals which protect against or sensitize to ionizing radiation depends greatly on better understanding of:

(a) The reactions of model and living systems to this radiation;
(b) The functional disturbances induced by them in multicellular organisms.

7. Information on the present state of knowledge of chemical radioprotection has not been widely disseminated and, in particular, radiotherapists tend to be unaware of the newer scientific developments in basic radiobiology and chemical radioprotection. The Panel strongly recommends that the Agency, in co-operation with WHO, arranges a meeting at which radiotherapists and

other workers that are involved with the effects of ionizing radiation on living organisms, animals and man could join with the radiobiologists to discuss practical applications of the information on radioprotectors now available.

8. Some knowledge of radiobiology is a necessary part of the normal curriculum of medical training and, in this context, it would be useful if the Agency, in co-operation with WHO, prepared a 'Manual on Pathophysiology of Radiation Damage', which should be made available to Medical Schools.

9. It would be valuable if the Agency called another Panel Meeting to deal specifically with radioprotectors and radiosensitizers.

Mar 21, 2012

Hi Jeff,

For beginners I'll tell you something about myself. Some things may please you and others may displease you. I should start right off by saying Steve Hinkley, a close local friend, told me today he will continue to receive e-mails from only you in my behalf. You seem to be the only one in my opinion who's got their head screwed on straight in the Tesla community. I will send you letters from time to time on matters you may find of interest. You do not need to reply in the same fashion but if you wish send an e-mail through Steve. We have a luncheon with friends on Fridays and he will give me copies of them in 18 ppt. size type.

I am very displeased with Gary Peterson. After publishing the first book in the Tesla Presents series under the name Sun Publishing, Peterson came into the picture saying he would like to publish the remaining two. proximity seemed like a good thing and I selected his company, twenty First Century Books. I didn't know much about him and half way through the second book he said he barley squeaked through high school and was happy to be given this opportunity. My heart sank. He made some terrible blunders on the third book which I felt was the most important. I suggested errata slips. He said no to that even though it would serve to protect his credibility as a publisher. Some people are unembraceable.

I have grown displeased with Bill Terbo in his management of his corporation. We both have informed him about Peterson but he has taken no action to remove him from the Board of directors. I was selected ad an honorary member of the board at the outset but if Bill does not remove Peterson soon I am inclined to ask that I be removed from the board.

Enclosed are a couple of items from my files that may interest you.

All best withes,

Lee

April 30, 2012

Hi Jeff,

Acknowledging you most interesting letter of April 2 nd.

The materials you have amused and the things you have accomplished concerning the work of Tesla are amazing. Congratulations.

Your report of the investigations of Dr. Joseph Dyer (is he an MD?) caught my particular attention. Years ago I prepared a document of remarks Tesla made in various published media of curious and surprising effects he observed when the coil at his Colorado Springs was operated at full power. One was that he could make X-ray plated 40(?) feet from the station.

Some day I wish you could visit my archive at the Historical Society of Western Pennsylvania in Pittsburgh. In terms of bulk, as shipped, it was 50 standard archive boxes, various other containers for large items. I no longer have any reference works and only copies of some articles. A few artifacts were donated, among these a violet ray kit containing a small Tesla coil used by some doctors a century ago.

My archive was joined in by Prof. Warren Rice of ASU giving a full file drawer full file cabinet drawer fill of documents on the Tesla turbine. He had his graduate students build and test various forms of Tesla turbomachinery. The bottom line is Tesla's parallel disc machines cannot reach the mechanical or thermodynamic efficiencies of other machines. .

Would you be interested in donating a modest size Tesla coil to this archive? I'm sure EE students at CMU would be delighted in setting it up for public demonstration.

All the best,

Leland Anderson

April 30, 2012

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Your report of the investigations of Dr. Joseph Dyer (is he an MD?) caught my particular attention. Years ago I prepared a document of remarks Tesla made in various published media of curious and surprising effects he observed when the coil at his Colorado Springs was operated at full power. One was that he could make X-ray plated 40(?) feet from the station.

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Would you be interested in donating a modest size Tesla coil to this archive? I'm sure EE students at CMU would be delighted in setting it up for public demonstration.

All the best,

Leland Anderson

May 7, 2012

Hi Jeff,

Received your e-mail from Steve Hinkley this past weekend. It is most thoughtful and generous of you to consider donating a Tesla coil and some other records to the Tesla archive in Pittsburgh.

You have told me something about yourself so I'll tell you about me.

I am a graduate of the University of Minnesota with an electrical engineering degree and a minor in atomic/astrophysics. For the first half of my working years I was employed by the computer industry as a design engineer. For the second half I was employed by the Fed as a computer system security officer and Freedom of Information/Privacy Acts specialist. I am a senior member of the IEEE and an associate member of the American Institute of Physics. I am a member emeritus of the Lightning Date Center and the Telecommunications History Group, both in Denver. As far as languages I took French about fifty years ago sufficiently fluent to translate Prof. Merigeault's paper, "Les Turbines a Frottments ou Turbines Tesla," appearing in *Revue Mechanique*. Merigeault analyzes Tesla's turbine as a friction machine. (Tesla dismissed the analysis.) I also had some knowledge of Serbo-Croation but if one is not in an environment where these languages are regularly used fluency is lost.

I'm sure you are aware of the books and articles I have written through the years on Tesla's work.

Le

Leland Anderson

Mar 30, 2012

Hi Jeff,

Your e-mails of March 26 (shorter one) and 27 sent through Steve read. I'll save the longer 26th 'til next week. I recall reading a note Tesla sent to Scherff mentioning the Waltham company.

What and where is the Turn of the Century Electrotherapy Museum? Please tell me something about it.

You might be interested in some things I've learned in my years.

First, William H. Terboyević, born April 10, 1930. Retired RCA executive. Bill assumed head of the Tesla Memorial Society founded by Nicholas Kosanović by means not clear to me legally except that he was a close friend of the Kosanović family. Bill then incorporated the society in his name with executive and director boards equaling the structure our electric power company operating with an annual budget of nearly a trillion dollars. Bill's society is a one-man operation it seems to me eljists for the purpose of familial aggrandizement

Bill's society predecessor, Kosanović, worked eljhaustively to broaden awareness of Tesla's many inventive gifts in our society. Kosanović published a newsletter and THE TESLA JOURNAL with continued until his passing and translated the correspondence between Tesla and his uncle in Serbia, which was a formidable task. I don't know of anyone else who would have taken time to do it, The draft copy was one inch thick before publication in book form. There was no question by those paying dues to the society whether the funds were being used well.

Bill Terbo, on the other hand, has done little or nothing along those lines He did appear on a documentary of the Westinghouse Company, talking about Tesla's work with the company, and I'm told he did a pretty good job.

However, what Ljubomir Voyević is complaining about is

Bill and his then wife taking annual sojourns to Serbia meeting with old friends and relatives paid for by dues to the society. I agree with Ljubo in this. Bill has never produced an annual budget report for members. I believe he is required to provide it to the IRS being a tax exempt nonprofit organization.. I;m sure members of the society would like to see this not the least of whom would be Ljubo. In event you are not aware of it I have asked Bill to remove my name as honorary member of the board of directors.

Secondly, I'll take up Gary Peterson with my neljt letter.

Are you a member of the IEEE?

All best withes,

Leland Anderson

April 15, 2012

Hi Jeff,

A printed copy of your March 29 e-mail telling about the letter you were sending was handed to me by Steve at our April 5 luncheon. The letter was received later that afternoon. I'll have time to get into it in a week or so. It seems that our communications are overlapping.

Thank you for the Priority Mail sending. The contents appear to be most interesting.

Please let me brief you on the degree of my vision loss. In numerical terms it is poorer than 20/2000. When visual perception is that low, a different scale is used and for me it is 06/40.

In my retirement I wanted to cease further active involvement in matters pertaining to Tesla, not that I'm no longer interested but leave me out of it. I had a dedicated e-mail address and phone number for Tesla matters and canceled them both. I wanted to relieve my partner and friends as well from further bother.

On the material you sent some of it is in 18 pt. which is fine. But with my hand-held video magnifier I am able to read only one word at a time. Anything more than one page is too tedious. So when warm warmweather is here I enjoy working in the garden on things I can do and spending the afternoons sitting on the patio with its beauty listening to birds sing and squirrels chattering.

Gary L. Peterson, 437 Summit County Road 528, Breckenridge, CO 80424. Breck is a nice skiing resort town. Gary has a cabin at the top end of the county road about a dozen miles from the town proper. I visited him at his cabin once quite a few years ago and the county road has a steep grade just before reaching his place. Some years ago he built an addition to his cabin for his book business inventory.

Gary is a recluse One might wonder about that. He rarely visits Denver. He has not had either a male or female companion.

Gary was associated with the old International Tesla Society in Colorado Springs. The society 1attracted a lot of interest at first, holding a conference every other year, taking over the entire Red Lion Inn. Almost every Teslaphile you've ever heard of attended. I was an invited guest to give a slide presentation, Bill Terbo gave a good talk and Bill Wysock put on a marvelous Tesla coil demonstration having a young fellow sit on top of a large coil with streamers leaping from thimbles on his fingers. Of course the conferences attracted the Tesla cult and local high school students.

ITS became a forum for the fringe. Membership of those not of that stripe waned.The wife of the society's founder, can't recall his name, divorced him and he left Colorado. A fellow named McGinnis, a tire dealer, was next in charge. He sniffed the liquid assets up his notes. The city foreclosed on the property for nonpayment of taxes. An auction was held on the front steps of the building. Someone described the scene for me. A small crowd gathered with McGinnis protesting the whole thing. A fellow from New Jersey put in a bid for everything and shipped it all back there.

This fellow started claiming he found documents on how Tesla planned to extract energy from the universe and sought investors to build a demonstration plant. The plant was never built, of course, and the SEC came after him sending him to prison.

All the best,

Lee

Leland Anderson

2008

MEMORANDUM

Irrationality

As a preface to this final chapter I should describe relatively recent findings of trauma to the human body from electrical and radiation sources. Several years ago I was invited to join a panel group meeting monthly in a conference room of a flight-for-life hospital in Denver, in fact the first hospital of its kind in the nation. Serious electrical injuries of all kinds are flown to the trauma center of this hospital. The panel group is headed by a nationally recognized neurologist and panel members are a rather eclectic group of neurologists, MDs, physicists, engineers, meterologists and others.

Certain similarities are being recorded for severe electrical trauma to the body. For example, a vine-like signature appears on the body at or near the area of incident. Of far greater concern, however, is harm to the brain that may not be diagnosed until some time later. Latency symptoms can include insomnia, difficulty concentrating on a topic, nervousness and loss of memory

The panel has also considered EM radiation effects on the brain, specifically from Cell phone use. The power of the transmitter in these phones was arbitrarily capped world wide, and it is yet too early to come to any conclusion. Study groups throughout the world are monitoring the problem. In addition to cell phone EM radiation, high tension power transmission lines are also of concern. If one approaches one of these towers today, transmitting electrical energy by Tesla's design, you will see a sign reading if you are close enough to read this sign you are too close to the tower. With that, I will now proceed with the final chapter.

In the years leading up to 1898, Tesla investigated electrotherapeutics. The only formal paper he presented to a scientific society was on this topic. During these investigations, one day Tesla placed a coil around his head strongly energized with high frequency currents. About this, he said he would never do it again. What caused him to say this was not mentioned. Now, of course, we can say this was a foolishly stupid thing to do. Also, when experimenting with X -rays and material stream emanations at about the same time, he developed large blisters on his hands from the rays. If a person went to a doctor today with such blisters and told him how they were caused, he'd probably freak out.

In private correspondence John O'Neill wrote to me that Tesla was suffering increasing periods of nonrationality when he knew him in the early '20s. I put it much earlier, 1900. O'Neill's correspondence file is in my archive in Pittsburgh. This was first noticed by me in his writings dealing

with measurement values. distorting the definition of horsepower, he claimed extraordinary values for his magnifying transmitter at Colorado Springs. For most measurement values, he employed a ridiculous number of significant digits or decimal digits. He was obsessed with his "Tesla" turbine, claiming unsupported thermal efficiency values. Prof. Warren Rice's files of work on the turbine by himself and his graduate students confirm this. Prof. Rice's files have been incorporated in my Tesla archive.

Tesla wrote extensively on various topics in the popular media. It remains an open question whether he chose it because the editors of these publications were not sufficiently technically educated to reject an article by him, relying solely on his early record of miraculous achievements. He immediately lost the technical communityt by expressing values such as 6,000,000,000 instead of 6×10^9 as appropriate in technical discussion. Your father wrote a letter to Tesla saying his stature would be better served if he would stop writing those ridiculous articles for those magazines.

In Tesla's 79th year, he prepared a 10-[age double-spaced press statement for his 80th birthday. Newspaper accounts of this birthday gave little mention of it, obviously to protect him and I respect the press corps for that.

Throughout the document Tesla attacks Einstein's theories of relativity. It was antithesis to his concept of wireless energy transmission. Tesla ridiculed the idea matter and force are transmutable. Tesla confused the size of an electron with a particle of tungsten the thickness of two sheets of standard copy paper, a billion times larger. He claimed to have solved the riddle of extending Faraday's disk generator which has been puzzling those interested for a couple of hundred years. Easy to claim but he didn't tell how.

There are other embarrassing ideas of Tesla in the press statement, and the original statement with Tesla's personal logo at the top of each page together with my commentary on it is in my archive in Pittsburgh. Do not think I am not sympathetic of Tesla. One cannot criticize someone who is mentally ill. It would be shameful to do so. Tesla was an extrovert and at this time in his life was unaware his remarks revealed his fallibilities.

Some time ago I was sent a faded clipping from the *Srbobran* carrying a photograph greeting the head of the exiled Serbian government. The date must have been in the early 1940s. Tesla's cheeks were hollowed and he looked like death walking. He was being held up by someone. How cruel. In building my photograph archive of Tesla I wanted to include a print of every photograph of him that had been published. But I did not want to see this photograph again and did not seek to obtain it from the *Srbobran* morgue file.

And so Tesla passed from this earth as he had lived, alone, with no one to hold his hand as he crossed that somber river.

LA
2525 SOUTH MEADE STREET
DENVER, COLORADO 80219

February 24, 2008

Dear Bill,

A Museum in a Troubled Land

I've gone through mixed emotions over this for the past fifty years. When the Muzej Nikole Tesle was established at Belgrade in 1952 I thought that's nice but Tesla did almost all his work here and his writings are in English. On the other hand, such a museum would never have been established in this country.

It's been most difficult for anyone here to do any research at the museum, not only because of the distance. First there was the cold war and the appointment of Tito who ruled all the republics with an iron fist to keep them quarreling. Thousands of Serbs were politically executed. Tito has been called Stalin's Trojan Horse.

The cold war was definitely a deterrent to anyone wanting to go over there. Ken Corum did and when we were in communication told me that he didn't dare go out on the streets at night for fear of getting his head shot off. When Cheney went over there, the only biographer to have made that trip by the way, the museum was most discourteous to her. Although making her plans way in advance, when she got there the museum said it was closed for remodeling. She got in only the last two days of here trip. She found all the index cards were in Serbian.

With the Berlin wall coming down and the cold war easing down, things improved generally. But then, Milosović came to power and stirred up all kinds of trouble again with his communistic rhetoric. For some reason the U.S. shot a missile into Belgrade. I'm not exactly sure about the reason. Not a good time for Tesla researchers to visit Belgrade then either.

Now Kosovo has seceded itself from Serbia and our president, of all things, ratified the agreement. It needed no ratification by the U.S . We had no business sticking our nose into that problem. So now the Serbian people themselves, not just the government, are angry with us over us and have burned our embassy there. We have now awak-

ened the hibernating Russian bear. Not a good time to visit Belgrade now for some time to come I would expect. As George San once wrote, "These are the sores of this planet we all regret. They must be burned out and healed with time."

MEMORANDA list

Thoughts

aT1 Aversion by the Institute

aT2 A very personal secret

aT3 Nonrationality

aT4 Intellectual inheritance

aT5 Undisclosed laboratory

Notes

bN1 Those who knew him well

bN2 Tesla and the U.S. Navy

bN3 Lillian (Mrs. James) McChesney

bN4 Artists

bN5 Note on Archives

bN6 George Scherff

bN7 Nonevents at Colorado Springs

LA
2525 SOUTH MEADE STREET
DENVER, COLORADO 80219

August 10, 2010

Bill,

Miscellaneous notes 7

Nonevents at Colorado Springs

O'Neill, in his Tesla biography, has been found to have invented several events. The biggest scape of misinformation taken as gospel by later writers concerns Coleman Czito's tale about what happened at Colorado Springs. He is the fellow who wanted to work for Tesla doing the experimental venture BUT Tesla sent him back after two days because he couldn't do the work Tesla needed.

Somehow, when O'Neill was working on the Tesla biography, he encountered Czito. Because of all the published matter by Tesla the preceding years, Czito embellished and exaggerated tales saying, "I was there!" Sure he was. One would have expected more from a science editor of a major newspaper to have swallowed Czito's yarns hook, line and sinker, to use an old Isaac Walton League expression.

Am I the only one to have caught the amazing coincidence of Czito saying Tesla transmitted power 26 miles at Colorado Springs (which neither happened nor could have happened–see my various writings on this subject) and the recorded earlier two-phase AC power transmitted 26 miles from Niagara Falls to Buffalo by Tesla's system? O'Neill must have been half-sloshed when he wrote this mistaken garbling.

Leland Anderson

CASE REPORT

The Journal of TRAUMA® Injury, Infection, and Critical Care

Lightning-Induced Injury on an Airplane: Coronal Discharge and Ball Lightning

Michael Cherington, MD, Philip R. Yarnell, MD, Judy Lane, MD, Leland Anderson, EE, and Gene Lines, EE

J Trauma. 2002;52:579–581.

We present a case of a flight attendant who suffered a lightning-related event shortly after take-off from the airport. Although the plane was struck by lightning, its flight course was not negatively affected. We believe the patient was touched by coronal discharges (CD) or, less likely, ball lightning (BL). Given his location in the rear of the aircraft, the description of an eyewitness, and the absence of any sighting of a moving ball of lightning, the diagnosis of CD is almost certain. In addition to the clinical discussion, we provide an analysis of the danger of lightning to the passengers and crew of aircraft.

CD and BL are poorly understood phenomena that have fascinated humans for centuries.[1–4] CD is a phenomenon of air breakdown when electric stress at the surface of a conductor exceeds a certain value. A glow, ranging in color from violet to yellow-gold, appears adjacent to the surface of the conductor. At higher voltage stress values, luminous discharge streamers occur. BL is an electrified luminous sphere that floats through the air or bounces along the ground and disappears in a few seconds. Its size varies from that of a golf ball to a basketball. On rare occasions, passengers and crew have witnessed a glowing ball traveling down the center aisle of the airplane. These glowing balls of electrical energy have been reported to dissipate quietly at the rear of the airplane, or to exit with a loud bang, leaving residual burn marks on the interior of the plane. The two differing final exits may be related to a range of the energy content of the glowing balls.

CASE REPORT

A 48-year-old flight attendant suffered a lightning-related event inside a commercial airliner. He was seated securely with four-point restraints in the aft (rear) section. At the time of the event, the plane had been delayed for several hours because of thunderstorms in the Chicago area. Twelve minutes into the flight, while still ascending, he began to feel a tingling throughout his body. Within a few seconds, there was a bright flash and loud boom. From the window on his left, he saw lightning strike the plane. Immediately after, another flight attendant, seated in the front and facing aft, saw a golden ball of light enveloping the patient for a brief moment. She then saw "electrical sparkles" emanating from his body. The patient was unaware of these happenings. He remembers his aft intercom telephone ringing and hearing the attendant in front inquiring if he was all right. Fifteen minutes later, as the flight stabilized, he removed the belt restraints and began his duties. His coworkers noted that the patient was briefly incoherent and remained mildly confused throughout the remainder of the flight. The odor of ozone was noted in the airplane, which often is present after electrical discharges.

When the flight landed, he went to his home. For the remainder of that day and night, he experienced nausea, headache, tinnitus, and numbness of his left upper extremity. He had insomnia that night. The next day he visited the company physician and was referred for neurologic consultation. His general examination was normal. He had intact tympanic membranes. There were no signs of skin burns or singed hair. At 2½ weeks, the neurologic examination revealed decreased pin and touch along the lateral aspect of the left arm. He had finger-to-nose ataxia in the left upper limb. Palpation tenderness of the cervical spine was noted. At that time he denied memory or cognitive difficulties.

At 10 weeks, he continued to complain of headache and insomnia. At this time, he was complaining of forgetfulness. On examination, he again had cervical tenderness and decreased pin over the left arm and mild ataxia of the left upper limb. EEG and EMG of upper limbs were normal. Audiometry was unchanged from baseline studies.

MRI of the brain obtained at 3½ months revealed multiple, small, white matter hyperintense lesions on T2-weighted imaging. Three of these lesions were periventricular (Fig. 1) and one was in the left cerebellar hemisphere (Fig. 2). They were interpreted as being consistent with demyelination. MRI of the brain at 22 months was unchanged. His cervical spine MRI was normal for age.

Neuropsychological testing at 5 months revealed moderate memory deficits in all modalities. Mild to moderate deficits in attention and concentration and moderate dysfunction of frontal lobe functioning were noted. He was mildly depressed.

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From the Lightning Data Center, St. Anthony Hospital (M.C., P.R.Y., J.L., L.A., G.L.), Departments of Neurology (M.C., P.Y.R.) and Neurosurgery (P.R.Y.), University of Colorado School of Medicine, Denver, Head Pain Center, Colorado Neurological Institute (J.L.), Englewood, and the Power Specialists Company (G.L.), Kittredge, Colorado.

Address for reprints: Michael Cherington, MD, Lightning Data Center, St. Anthony Hospital, 4231 West 16th Avenue, Denver, CO 80204.

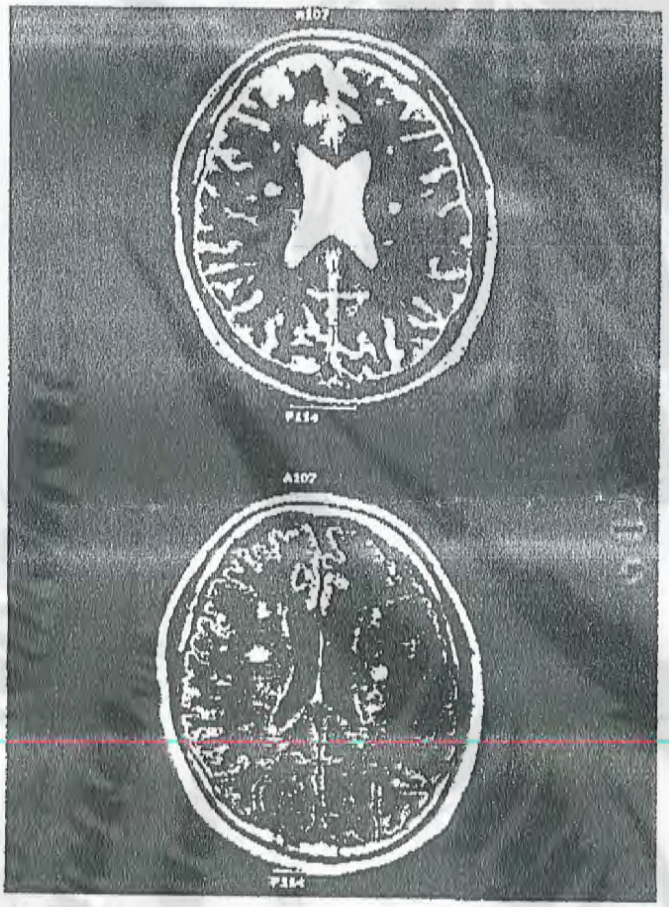


Fig. 1. *T2-weighted and fluid-attenuated inversion recovery axial images demonstrating periventricular white matter hyperintense lesions.*

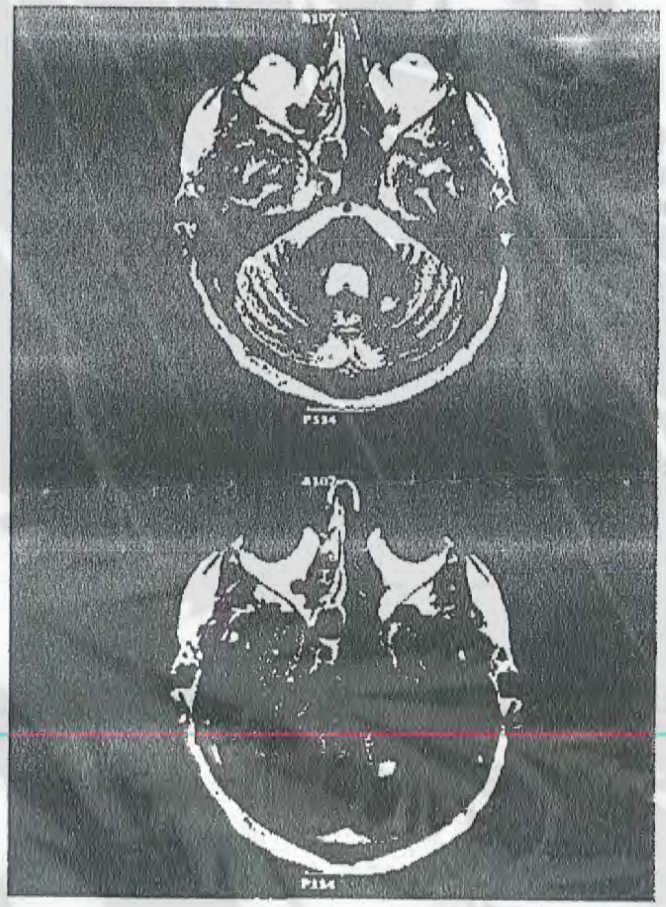


Fig. 2. *T2-weighted and fluid-attenuated inversion recovery axial images demonstrating 6-mm hyperintense lesion in the left cerebellar hemisphere white matter.*

At 22 months, he continued to demonstrate forgetfulness, difficulty maintaining a coherent stream of thought, and left upper limb clumsiness. He was being treated for persistent headaches and was receiving cognitive rehabilitation therapy.

DISCUSSION

Lightning strikes are responsible for about 100 fatalities and over 1,000 casualties each year in the United States.[5,6] These serious calamities have been categorized and reported in the medical literature.[7–9] CD and BL phenomena are less well defined and not usually associated with medical symptoms or signs. We could not find any report of CD injuries.

The patient reported here suffered injuries from an induced electrical event shortly after the plane had taken off in a thunderstorm. In this case, we postulate that a rare combination of circumstances resulted in high-current resonances producing localized high voltages exceeding critical air discharge values in the interior of the airplane with resultant corona. To our knowledge, such an intense electromagnetic resonance in an airplane resulting in a CD injury has not been previously described in the medical literature.

It is significant that our patient has typical prolonged neuropsychological sequelae related to his experience with this lightning-related CD phenomenon. In this regard, he resembles some patients who suffer conventional injuries in lightning strikes.[10] Cognitive problems are frequent sequelae in lightning strike survivors. In many ways, they resemble the problems that afflict patients recovering from mild traumatic brain injury. Sleep disorders and memory impairment are often prominent symptoms in lightning survivors. Survivors also undergo a diminished capacity to function both occupationally and socially. Our CD/BL patient's symptoms, evaluations, and symptomatic treatments are similar to those seen in other lightning survivors.[11]

Our patient's MRI of the brain revealed multiple, small, white matter hyperintense lesions interpreted as being consistent with demyelination. The clinical significance of these findings is in doubt. We know of several electrical trauma patients, and two other lightning injured patients, where subsequent MRI studies showed white matter abnormalities on T2-weighted imaging. The relationship of these MRI findings

to the electrical trauma and the lightning-related events is problematic.

CD within in-flight commercial airliners is different from previous documented occurrences of BL. Accounts of BL in an airplane are rather uniform with regard to the size and movement of the glowing sphere. In this case report, a well-defined moving ball was not observed. Rather, a large luminous corona spherical cloud enveloped the flight attendant.

Because of its short duration (seconds) and unpredictable appearance, passengers and crew have not been prepared to photograph BL/CD. In the near future, BL/CD may be seen on videotape. Why? International commercial airlines are considering placing video cameras on planes to record acts of plane rage or other antisocial behavior.[12] If and when cameras are installed, BL/CD may be captured on tape.

Most accounts of people coming in contact with BL are anecdotal. It has been assumed that BL is a low-energy phenomenon because, as compared with lightning strikes, BL injuries either have not occurred or have been slight. CD may result in a higher level of transfer of electrical energy. Even though the electrical charges that produce CD can be dangerous, we know of no previously published reports in the medical literature of human injuries from CD in an aircraft.

Is Lightning Dangerous to Passengers and Crew of Airplanes?

Although a few major airplane lightning-related disasters have occurred, most of the time passengers and crew of commercial flights survive lightning storms.[13] Lightning strikes to commercial airplanes in flight are relatively common, yet passengers and crew are seldom injured.

When a commercial aircraft with an electrical charge comes near or enters a thundercloud with an electrical charge of opposite polarity, the energy differential is present for a lightning strike to the aircraft. The injuries caused by such a lightning strike are usually minimal because there is minimal current flow into the interior of the plane. This is known as the Faraday cage effect. In most cases, the damage to the aircraft is a burn hole smaller than the size of a pencil.

To our knowledge, CD and BL have not been responsible for death of any occupants of airplanes. There have been reports of BL causing burns of aircraft interiors and burns of the hair of occupants. We believe the case reported here is the first in the medical literature where the occupant of an airplane has suffered long-term effects from a lightning-induced electrical event (CD).

CONCLUSION

We present a flight attendant who suffered prolonged neurologic sequelae from lightning-induced CD during flight. To our knowledge, before this case report, no one has ever been seriously injured from CD or BL in an airplane. This electrical accident occurred immediately after the plane was struck by lightning. CD and BL are real but poorly understood phenomena. Lightning-related disasters on airplanes are uncommon.

ACKNOWLEDGMENTS

We thank Dr. Karl Gross for his interest and the patient referral. We thank L. David Cherington for his helpful suggestions. We thank Jeffrey Sellon, PE, and Nancy Cherington for their review and comments.

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TESLA files (20 from Anderson's electronic rchives)

American Red Cross announ. Jan. 7, 1900

BEHREND, BERNARD A. (bio. sk.)

Brand, Wallace E. on Tesla 15 pp.

Funeral at St. John the Divine

In Quest of the Light (90 min video)

Lectures/Papers 1888-1899

Matter & Force Statement Nov. 11, 1934

NOTES re. TESLA from Swezey

Pennsylvania Hotel Medallion text by me

SCHERFF COLLECTION to Col. U. - how

STATEMENT ON ARCHIVES (my eeefforts)

Tesla letter to Luka Dec 16, '99 re. Mr. Alley

Tesla letter to Luka Feb.23, 1899 re. Kipling

Tesla letter to Morgan Mar. 5, 1905 re.failure

Tesla ltr to Westinghouse Co. Feb. 24, 1899

Tesla note to Scherff Jan. 17, 1936 - sad

TESLA-MASTER OF LIGHTNING, Uth/Cheney

TM microfilming I recomd. to L/C 1958

V.P Wallace's fwd to Serb ed. book (Oct. '42)

VREME 1994 Beograd exhibition (translation)

TESLA'S FUNERAL AT ST. JOHN THE DIVINE CATHEDRAL

Tesla's funeral coming at the end of Epiphany required a frantic rush to remove the Episcopal decorations of this period of celebration in order that the casket could be brought into the cathedral. Serbian Orthodox services were conducted by Very Rev. Dušan Šukletović, assisted by Very Rev. Milan Mrvičin. At the conclusion of the requiem, Rev. Edward West read the Episcopalian liturgy. With organ accompaniment, Bishop W.T. Manning, head of the Protestant-Episcopal Diocese of New York gave the final benediction.

Honorary pallbearers:

Sava Kosanović, chief mourner
PRES., EASTERN AND MIDDLE EASTERN COMMITTEE FOR PLANING

Constantin Fotić, leading the procession
YUGOSLAV AMBASSADOR TO THE U.S.

Dr. E.F.W. Alexanderson
GENERAL ELECTRIC CO. (INVENTOR OF THE ALEXANDERSON ALTERNATOR)

Prof. Edwin H. Armstrong
COLUMBIA UNIVERSITY (INVENTOR OF FREQUENCY MODULATION)

Prof. William H. Barton
CURATOR , HAYDEN PLANETARIUM , AMERICAN MUSEUM OF NATURAL HISTORY

Col. Henry Breckenridge
RET . ASS 'T SECRETARY OF WAR, COMDR. NATIONAL ARMY, LT. COL INFANTRY

Dr. Branko Cubrilović
YUGOSLAV MINISTER OF AGRICULTURE AND SUPPLY

Gano Dunn
PRES., J.C. WHITE ENGINEERING CORP.

Oskar Gavrilović
CHIEF, PRESS BUREAU , YUGOSLAV INFORMATION CENTER

Bogoljub Jeftić
MINISTER OF YUGOSLAVIA

Newbold Morris
PRES., NEW YORK CITY COUNCIL

Bogdan Radića
YUGOSLAV INFORMATION CENTER

Prof. Paul Radosavljević
NEW YORK UNIVERSITY

Dr. Harvey C. Rentschler
DIR., RESEARCH LABORATORIES , WESTINGHOUSE ELECTRIC AND MANUFACTURING CO.

David Sarnoff
PRESIDENT , RADIO CORPORATION OF AMERICA

George Skouras
PRES., TWENTIETH CENTURY FOX

Franc Snoj
MINISTER PLENIPOTENTIARY OF YUGOSLAVIA

Dragisa M. Stanojević
COUNSEL GENERAL , YUGOSLAVIA

Dr. Ivan Šubačić
GOVERNOR OF CROATIA , REPRESENTATIVE , INTERNATIONAL RED CROSS

In a letter dated October 22, 1957, Martin Cornelius, a friend of the Serbian Orthodox Church in Gary, Indiana, wrote, "Rev. Šukletović told me today that he does not know what eventually happened to the body. He did not accompany the funeral to the cemetery crypt rented up the Hudson River. Tesla's nephew wanted cremation and Rev. Šukletović's Bishop and Rev. Šukletović would not be a party, or parties, to this. For all that Rev. Šukletović knows today, the nephew may later have cremated the body and taken the ashes back in an urn to Yugoslavia" (which transpired a decade later).

Kenneth Swezey, who remained Tesla's closest friend, was also in attendance. In a letter to the then Secretary of the Institute of Radio Engineers, Swezey wrote, "I learned about his death early the following morning, and got to the hotel before he had been removed from bed. He had wasted away terribly during the last few years of his life... I was the only personal friend who accompanied Tesla's remains to the cemetery." (Interview of Swezey by Julian Tebo, IEEE)

John J. O'Neill, Tesla's first biographer, was not present at the funeral service, He was in a sanitarium being treated for alcoholism.

LA
2525 SOUTH MEADE STREET
DENVER, COLORADO 80219

June, 2012

Jeff,

Steve gave me a printed copy of your May 31 e-mail at our usual Friday noon luncheon on June 1. I appreciate either or both of you for using 18 pt. type size.

Below is the shipping label address I use sending matter to the historical society in Pittsburgh. It carries all the information you need contacting someone there by phone or e-mail.

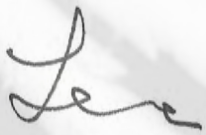
Historical Society of Western Pennsylvania
Attn: Theresa E. Reh,
Acquisition Archivist
History Center
1212 Smallman Street
Pittsburgh, PA 15222

Quite a long time ago I visited Ken Strickfaden in LA. We spent the entire time in his garage-converted workshop which I thought rather small for the marvels he produced for the motion picture industry. Ken was short in stature and jovial, full of humor. We entered into a lot of correspondence and he always drew a small Tesla coil schematic alongside his signature.

Harry Goldman passed away Oct. 16, 2010. Toward the end when he was failing I'd send notes to Ruth for her to read to Harry and maybe cheer him up. Harry's lab, which he called barn, was full of all kinds of apparatus including Van deGraff generators. I haven't approached Ruth on what she intends to do with it because there may be some sentimental attachment. I'll let someone else do that!

I'm finding it difficult to do things now. I will respond to communications as I can but I will no longer be initiating any.communications but will acknowledge all received as I can.

Best wishes.



March 10, 2008R

Bill,

Adversity by the Institute

The narrative for this memorandum begins in October, 1956, at the Fall General Meeting of the AIEE observance of the Tesla centennial including a luncheon with speakers offered by the Tesla Society. Richard Sogge, who was the institute's delegate to the observance in Belgrade, wanted to have a talk with me in my hotel room. He said that it was a good thing the Institute was honoring Tesla in this way and also a private society. He went on further saying that the old timers in the Institute were uneasy about Tesla and rumors spread that he might be a night voyeur, given the fact that he never married, and some day the whole thing might hit the papers and embarrass the Institute. But, Sogge said, those old men will die off and their prejudices forgotten. Well, it hasn't to this day.,

You may imagine how angry I was at the Institute on hearing this. I've always felt that Tesla should have a medal at the same level as Edison. When I came to Denver I read thoroughly the Institute's constitution and by laws pertaining to the establishment of any award. It turned out that of a committee made up of several individuals Barney Finn was included. Nevertheless I prepared a formal proposition to the Institute on the establishment of a Tesla Medal.

The reply I got was disheartening.The Institute did not object to the proposition, but the work of contacting a consortium of the power industry to sponsor the medal would need to be undertaken by myself. Never mind the fact that it was the institute that organized sponsors for the Edison Medal.

If I were of younger age now I would go after the computer industry to establish an Institute gold medal on par with the Edison medal. Bill Gates and the corporate board of Apple each have founded notablephilanthropic foundations. Tesla's invention more than a hundreded years ago of the AND logic gate circuit element is basic in all the digital technology in the world. American ingenuity made it a reality. It would be a marvelous tribute to Tesla for Bill Gates and the corporate board of Apple, fierce competitors, to shake hands and together establish an Institute gold medal for Tesla.

Leland Anderson

NOTE:

This lecture was never published.
As of this date (10-12-86) the only copies that exist in the United States are this one, a copy for Margaret Cheney, and a copy for Prof. James F. Corum. All have been advised not to make known ownership of a copy.

08-14-90
Dave copy to Toby Grotz (then ± p. 42)
Leland Anderson → Jeff Berry

Nikola TESLA:

LECTURE BEFORE THE NEW YORK ACADEMY OF SCIENCE,
April, 6, 1897.

Fotocopy from the "Nikola Tesla Museum",
Belgrade, Yugoslavia - file No. 2105

2105

Lecture before the New York Academy of Science, April 6, 1897.

MUZEJ NIKOLE TESLE

Ladies & Gentlemen:-

You will still remember vividly, no doubt, the excitement which a year ago was caused by the announcement of the discoveries of Prof. Roentgen. Suddenly, without any preparation, Roentgen surprised the world with two wonderful results. He showed us how to take a photographic impression of an object invisible to the eye and, what seemed still more extraordinary, he enabled us, by the help of his luminous screen - now known as the fluoroscope - to see, with our own eyes, the outlines of the object. We are living in an age of exceptional intellectual activity, and important advances are often recorded, but these were almost of the order of the telescope and microscope and such discoveries come no more than once or twice in a century. Scarcely can any one of us ~~hope~~ to again witness in his lifetime an event of so wide-spread a scientific and popular interest. The desire to see things which seem forever hidden from sight is more or less strongly developed in every human being, through all degrees of this sentiment, from the idle curiosity of the unenlightened to the absorbing desire for knowledge of the highly refined, and this in itself was sufficient to engage universal attention; but, apart from this, these discoveries brought promise of relief to numberless sufferers and stirred all over the world the fibres of humanity. It is hardly necessary for me to

tell you that the fever took hold of me also, but mine was a singular, grave case, and I have not recovered from its effects to this day. I hope you will pardon here a slight digression which I have a strong reason to make.

MUZEJ NIKOLE TESLE

At the close of 1894, realizing the necessity of recovery from a straining task, on which I have been laboring for a number of years and which still commands my energies, it occurred to me to investigate the actinic action of phosphorescent bodies. The subject did not appear to have been studied, and I began the work at once, securing later, at the suggestion of some friends connected with the Century Magazine, the assistance of Messrs. Tonnelé & Co., artists' Photographers, of this City, then doing work for this Magazine. In these experiments I employed an improved apparatus for the production of powerful electrical vibrations, as well as one of my high frequency alternators of old design. A great variety of Crookes tubes, single-electrode globes and vacuum bulbs without external electrodes were experimented upon. A surprising fact was soon brought to light; namely, that the actinic power of the Crookes bulbs varied greatly and that some, which emitted a comparatively strong luminosity, hardly showed an effect, while others, of much smaller light-giving power, produced strong impressions. I wish to state here, in order to be clear, that my efforts were directed towards investigating such actions of true phosphorescent light, as furnished from bulbs without appreciable emission of heat,

and not so much those of incandescent vacuum tubes, although some photographs were likewise taken with these. As both the artists and myself were busy on other matters the plates in their ordinary holders were frequently put in some corner of the laboratory until a suitable opportunity for carrying on the experiments was found. During these investigations many plates gave a result, while many others failed, and on some of these both Mr. Alley, who then assisted me, and myself noted unaccountable marks and defects. Mr. Alley particularly found it extraordinary that, in spite of his care, many plates proved defective and unsuccessful. The taking of these photographic impressions by means of Crookes bulbs brought freshly to my mind the experiments of Lenard, some features of which, particularly the action on a sensitive plate, had fascinated me from the start, and I resolved to go over the ground covered by him with assistance and improved appliances. Just as my attention was arrested by this feature my laboratory with almost everything it contained was destroyed; and the few months following passed in intense activity which made me temporarily forget my projects. I had hardly finished the work of reconstruction and resumed the course of my ideas when the news of Roentgen's achievement reached me. Instantly the truth flashed upon my mind. I hurried to repeat his incompletely reported experiments, and there I beheld the wonder myself. Then -too late- I realized that my guiding spirit had again prompted me and that I had failed to comprehend his mysterious signs.

MUZEJ · NIKOLE TESLE

The statement of these facts might have been misinterpreted at the time of Prof. Roentgen's announcement, and I have kept silent, although I was unable to overcome entirely my feeling in the introductory lines of my first of a series of articles I wrote on this subject in the columns of the Electrical Review. Presently, however, I have no fear of a misunderstanding of my words, and I am recording my painful but stimulating experience solely to make some of those, who have lightly written about the history of this new art, more justly appreciate this new departure. I was quite well acquainted with the results of Lenard and naturally often thought of his beautiful and promising experiments, and yet the possibility of the plates being marked and spoiled by some action of the bulbs never presented itself to my mind. While some might see in this only an argument for my own short-sightedness, others, more kindly disposed towards me, will, with myself, consider it rather a demonstration of Goethe's great words, which I will not repeat in the text, but which say that, what Nature does not want to reveal to one's mind, one cannot force it from her with screws and levers.

MUZEJ NIKOLE TESLE

But while I have failed to see what others in my place might have perceived, it was always since my conviction, which is now firmer than ever, that I have not been forsaken by the kind spirit who then communed with me, but that, on the contrary, he has further guided me and guided me right in the comprehension of the

marvellous
nature of these manifestations. Perhaps, in bringing to your attention some new facts which I have since discovered in addition to those already announced, I may induce, at least some of you, to interpret these phenomena as I do. For fear, though, that I might miss my chief object this evening, I must ask your kind indulgence to dwell in a few words on the novel appliances which are exhibited here for your inspection. When I trace their origin I find it clearly in my early recognition of the fact that an economical method of producing electrical vibrations of very high frequency was the key for the solution of a number of most important problems in science and industry. Insignificant as these machines may seem to you, they are nevertheless the result of labors extending through a number of years, and I can truthfully say that many times the difficulties which I have encountered in my endeavors to perfect them, have appeared to me so great as to almost deprive me of the courage to continue the work. When the experimenter has to spend several years of patient effort only to recognize that a mere microscopical cavity or air bubble in the essential parts of his apparatus is fatal to the attainment of the result sought for by him; when he has to find that his machine does not perform well because a wire he uses is a quarter of an inch too long or too short; when he notes that now a part of his apparatus when in action will grow colder in an apparently inexplicable way, and next that the

MUZEJ NIKOLE TESLE

same part will get overheated, though to all appearance the conditions are unchanged; when he makes puzzling observations at every step and ordinary instruments and methods of measurement are not available, then his progress is necessarily slow and his energies are severely taxed. Finally, I am glad to say, I have triumphed over at least the chief obstacles, and nothing of any serious consequence stands now in the way of obtaining electrical oscillations of frequencies up to a few millions a second from ordinary supply circuits with simple and fairly economical appliances. What this means I need not discuss. It will be duly judged by those who have kept in touch with the development in this and allied fields. These machines you see are only a few of the types I have developed and as they stand here they are chiefly intended to replace the ordinary induction coil in its numerous uses.

MUZEJ NIKOLE TESLE

As to the broad principle underlying these transformers or electrical oscillators, as they might be most properly called, it is simple enough and has been advanced by me some five or six years ago. A condenser is charged from a suitable source and is then in any convenient way discharged through a circuit containing, as it does here, the primary of the transformer. The first diagram here, fig 1, illustrates a generator (G), a condenser (C) and for charging and discharging the latter any kind of device (D) adapted to produce an intermittent break in the dielectric. The circuit (L) containing the light or low tension through which the discharges condenser discharges being properly adjusted, extremely rapid elec-

trical vibrations which, so far we know, are unattainable by any other means, result; and these set up by inductive action in any neighboring circuits similar vibrations which give rise to many curious phenomena. Having familiarized myself with these at the time when some laws governing them were not quite well understood, I have retained certain conceptions which I have then formed and which, though primitive, might stand even now in the light of our present advanced knowledge. I have likened a condenser to a reservoir (R) into which an incompressible fluid is supplied through a feed-pipe (F), as illustrated in the second diagram, fig. 2, the fluid representing electricity. The reservoir has a movable bottom, held up by a spring (S) and opens when the fluid has reached a certain height and the pressure has become sufficient to overcome the elastic force of the spring. With the giving away of the bottom the fluid in the reservoir acquires velocity and consequently momentum, which results in an increased pressure against the bottom, causing the latter to open wider, and more of the fluid rushes out than the feed-pipe can supply, whereupon the spring reasserts itself, closing again the ports, and the same process is repeated in more or less rapid succession. This opening and closing of the bottom may be likened to the making and breaking of the conducting path, the frictional resistance in this mechanical system to the ohmic resistance and, obviously, the inertia of the moving masses to the self induction of the electric

circuit. Now it is evident that, in order to keep in action the mechanism without the employment of auxiliary means, the average rate of supply through the pipe must be inferior to the average rate of discharge through the bottom; for, if it be otherwise, the ports will simply remain open and no vibration will take place. The more nearly the average rate of supply equals the average rate of discharge the quicker will the bottom open and close; and it is furthermore clear from a consideration of simple mechanical principles that, if the fluid be supplied so fast through the feed-pipe that the bottom vibrates as it would of its own accord, then the amplitude of the vibration will be the largest, the pressure against the bottom the strongest and the greatest amount of fluid will be passed through the ports. All these considerations hold good for the electric circuit, and in experiments with high-frequency machines, in which these effects were purposely magnified with the view of rendering their observation more easy, I have found that that condition is fulfilled when the capacity, self-induction and frequency of vibration bear a certain relation, which observation I have since utilized in the adjustment of inductive circuits. You will note that this condition governing the rate of supply and discharge, most important in practice, especially when no positively acting mechanical means are employed for effecting the rupture of the dielectric, is a distinct one and should not be confounded with the condition de-

MUZEJ NIKOLE TESLE

termining the oscillatory character of the discharge investigated long ago by Lord Kelvin.

MUZEJ NIKOLE TESLE

The next step in the evolution of the principle and its adaptation to practical uses was to associate with the system illustrated in fig. 1 a self-induction coil, L, as shown in diagram fig. 3, which modified the action in many now well-understood ways. In a simplified form of this arrangement the condenser, as a distinctive part of the system, was done away with, the necessary capacity being given to the coil itself, and for this purpose the turns of the latter were wound as illustrated in fig. 4, so as to allow the storage of the largest possible amount of energy. Then I associated a secondary coil, S, with the primary circuit, P, as shown in fig. 5, this enabling the obtaining of any tension required. After this the arrangement in diagram fig. 6 was adopted as best suitable for the existing municipal circuits. Again the self-explanatory diagram fig. 7 typically illustrates a further improved disposition as used in some of these machines with two or more circuits. A modification of this plan with one continuous contact, common to the two circuits and independent interrupters for each of these allows easy adjustment of the phase of the currents through the primary, which is of practical advantage in some uses of the apparatus. Finally, in diagram fig. 8 is shown the exact arrangement of the parts and circuits of one of these small oscillators with a break similar to that usually employed in connection with induction

coils. Although the majority of the preceding arrangements have been described by me before I thought it necessary to dwell on them here in order to present clearly and comprehensively the subject.

MUZEJ NIKOLE TESLE

A specific result of value in the operation of Roentgen bulbs is obtainable by the use of two circuits linked as shown in Fig. 7, or otherwise, or entirely independent with two separate primaries. Namely, in the usual commercial bulbs the vacuum gets higher when the current is passed through the primary in a certain direction and is lowered when the direction of the current is reversed. This is a direct consequence of some conditions which, as a rule, are present in the operation of the usual apparatus; that is, the assymetry of the opposite current impulses, the unequal size, configuration or temperature of the two electrodes, or like causes which tend to render unequal the dissipation of the energy from both the electrodes. It should be stated, though, that beyond a certain point, when the electrodes begin to act as entirely independent, the vacuum continues to increase, no matter which way the current is passed through the primary. In the scheme illustrated in fig. 7 or in its modifications referred to the trouble attendant upon the operation of ordinary apparatus is practically done away with, as the current through the primary is automatically reversed, and in this manner a tube which is first brought to the proper degree of exhaustion by means of one circuit can be worked for a long time without appreciable increase of vacuum or diminution of effectiveness.

A photograph of one of these finished instruments, (fig. 9) especially adapted to be used in the operation of Roentgen bulbs, or in general as a laboratory appliance in place of the ordinary induction coil gives an idea of the actual arrangement of the parts. The condenser (C fig. 8) is contained in a box B upon which is mounted in front the motor for controlling the circuits, in this instance simply a coil L actuating a spring (S), fixed on top of the same. This coil, designated as the charging coil, serves at the same time to raise the pressure of the source to any value desired for charging the condenser. This is an important practical advantage, as it enables to reduce the capacity of the latter, so that it need not be more than a few percent of that otherwise needed for an equivalent conversion of energy. Besides, the smaller the capacity, the quicker is the vibration and the shorter need be the high-tension secondary. The discharge circuit P surrounding the secondary coil S is formed of a few turns of copper ribbon and mounted on the top of the box behind the charging coil, all connections being as short as possible, so as to reduce as much as it is practicable both the self-induction and resistance of the discharge circuit. On the front side of the box (fig. 9) containing the condenser there are mounted the binding posts for connection with the line, two small fuses and a reversing switch. In addition two adjusting screws are provided for raising and lowering the iron core within the charging coil as a convenient means for varying within considerable limits the current of supply and regulating thereby the discharge of the secondary circuit.

MUZEJ NIKOLE TESLE

rubber columns carrying

The instrument with the discharge rods, which are visible on the top, dismounted, can be inclosed in a box of 12x9x6 inches inside measure.

The mode of operation may be explained as follows. At (see fig. 8) the start, the spring contacts being closed and the condenser practically short-circuited, a strong current passes through the charging coil, attracting the armature fastened to the spring and separating the contacts. Upon this the energy stored in the coil, assuming the form of a high-tension discharge, rushes into the condenser, charging the same to a high potential. The current through the coil now subsiding, the attraction exerted upon the armature ceases, and the spring reasserts itself and closes again the contacts. With the closing of the latter the condenser is discharged through the primary or discharge circuit, the constants of which are so chosen that an extremely rapid vibration of the electro-magnetic system, including the condenser and primary coil, results. The currents of very high frequency thus obtained induce corresponding currents of high tension in the secondary. Simultaneously, however, with the discharging of the condenser the current from the source of supply again rushes through the charging coil and energy is stored for the next charge of the condenser, this process being repeated as often as the spring opens and closes the contacts.

MUZEJ NIKOLE TESLE

Although the instrument contains all the essentials of an ordinary induction coil, it will be seen that its action is entirely different, and the advantages of this new principle over the old

are so great as to hardly require any lengthy comment. Merely to convey a true and more complete information I may mention a few of the most important ones. Take, for instance, the economy. The instrument referred to takes on a 110 volt direct current circuit, according to load and adjustment, from 5 to 30 watts. It gives a powerful stream of sparks 6 inches in length, but if it be desired this distance can be easily doubled without increasing the energy consumed; in fact, I have found it practicable to produce by the use of this principle sparks of a foot in length, involving no greater expenditure of energy than 10 watts. But in an instrument designed for a variety of uses a departure must be made from a design insuring the greatest spark-length. Of the total energy consumed by the apparatus fully 80 percent can be obtained in the secondary circuit. Owing to the small total energy consumed and the efficiency of conversion all parts of the instrument remain cool by long continued working, with the exception of the contacts which, of course, are slightly heated. The latter are subject to much less deterioration than is commonly the case, as the current from the condenser is small and moreover, does not, like in an ordinary coil, pass simply through the contacts and a few short connections, but has to traverse the primary coil, this reducing the current and diminishing very much the heating effects.

MUZEJ NIKOLE TESLE

Consider next the advantages of the absence of fine wire in the secondary coil. Owing to the rapidity of vibration of the primary currents comparatively few turns of thick wire give the required pressure in the secondary circuit. To illustrate this fea-

ture by a practical experiment I take a simple paper cylinder, wound with only one layer of ordinary magnet wire, forming the secondary coil. In spite of there being only a few turns long sparks, several inches in length, are obtained, when the coil is inserted within or brought near to the discharge circuit of the instrument. A secondary of this form is simplest and best suitable for the production of long sparks, but it is somewhat inconvenient to handle.

The most advantageous features of these instruments lie, however, in the quality of the effects produced, which are the result of the rapidity or suddenness of the discharges obtained. To appreciate this feature we only need consider that a spark of, for instance, 6 inches in length, obtained with an instrument giving half a million vibrations a second, involves maximum pressures which, if produced with ordinary methods, would give sparks of many hundred feet, since the electrical force necessary to vibrate a certain quantity of electricity increases very rapidly, that is, with the square of the frequency of vibration. Therefore, pressures such as these here obtainable cannot be secured in any way by static machines or ordinary induction coils.

MUZEJ NIKOLE TESLE

Still another feature of a more practical bearing I may illustrate by lighting a vacuum tube from an instrument furnishing currents of a frequency of much over half a million a second. Although the tube has a volume of only about two and a half inches it emits more light than a tube six or seven feet long and one and a half

inches in diameter, such as I have shown on other occasions, and that is a tube having sixty times the bulk and taking a proportionately larger amount of energy. So small a tube as this shown could not at all be brought to this luminosity by the use of the ordinary currents without getting soon overheated, and no better test of the increased efficiency of light production can be had than by producing so high a luminosity in a small tube without undue heating.

Another convenient and advantageous feature of such an instrument will be found in its capability of being operated from alternating as well as from direct current municipal circuits. With the special object in view of enabling their being used to the best advantage on alternating circuits also I have determined the physical constants in a few types to suit circuits of the frequencies usually adopted here, that is 60 or 125 cycles persecond.

MUZEJ NIKOLE TESLE

In the development and practical application of the principle underlying this kind of apparatus one of the greatest difficulties encountered was the insulation of the secondary coils and condensers, particularly of the latter. The stored energy of a condenser is of an explosive nature, and when released suddenly in a way as it is in these instruments it partakes much of the character of explosions of such a body as dynamite, and enormous maximum pressures result, which strain the dielectric layers in the condensers and coils to their utmost. No matter how good and thick an insulation is provided it cannot withstand such strains, if there be even a

slight absorption loss caused in any strained portion of the apparatus. An ordinary condenser, insulated as usual by thick layers of mica, which easily stands a few thousand volts of steady or slowly varying pressure, breaks down invariably; and no wonder it does; for, with vibrations of several hundred thousand a second, such a condenser with air-bubbles or cavities of any kind, unavoidable when the usual method of construction is followed, will convert into heat the larger portion of the energy supplied to it.

To investigate the flow of an alternating current through a coil with an iron core which is not laminated is hardly less crude than to carry on a research of rapid electrical vibrations with a condenser in which there are cavities or air-bubbles, or in which, in general, air has access to the highly charged conductors. No estimate of the vibration period of an electro-magnetic system can in such a case be made with any accuracy, whereas, when a proper plan of construction is followed and the dissipation of energy obviated, the experimental result closely agrees with the calculated period.

By properly building up the condensers and coils I have produced electro-magnetic systems in which a slow vibration, once started, continues a minute or more, this indicating the absence of any serious friction loss. It is important to consider the preceding facts when dealing with standards and instruments of measure. A standard condenser prepared in the ordinary way of mica sheets and tinfoil, while indicating the correct value of capacity when used with a steady or slowly varying potential, will have its measured

MUZEJ NIKOLE TESLE

capacity greatly increased when the variation of potential becomes extremely rapid. In like manner an electrostatic voltmeter with its vanes immersed in air, though a precious instrument with ordinary currents, is practically useless in the measurement of condenser discharges of frequencies of a few hundred thousand a second, its indication being far too low.

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In view of the importance of the subject a few words on the process of insulating which has been adopted by me after several years of experimentation, may be of value. One form of apparatus as used by me is illustrated in diagram fig.10. A is a tank capable of withstanding great pressure, which is connected to a pump E and its reservoir H through a condensing reservoir F, kept cool by means of the coil pipe G. The tank A is likewise provided with a coiled pipe C, through which either steam or cold water may be passed at will. The condenser is built up of insulating and conducting sheets in any convenient way, several layers of very thin paper being put together, so as to avoid defects which may arise from small holes or punctures. For the same reason it is advisable to mix up the sheets when received from the factory, as a great number of them may be injured at the same place. The condenser c having been tested by the application of moderate electrical pressure as that of a supply circuit of 220 volts is placed in a tapering vessel B. A pipe D, reaching to the bottom of this vessel, may be provided, through which the insulation, when liquefied by the heat, may flow in, but this is of less importance. The vessel B containing the condenser being next placed in the tank

A and the top of the latter bolted down, steam is then passed through the coil pipe C and the insulating mass is kept at the right temperature (which is a little above the melting point of the compound) by regulating the steam supply. The pump is now connected with the tank by opening the proper valves and a vacuum of about 29 inches or slightly more is established. When the melted compound has thoroughly permeated the interstices of the condenser, steam is then shut off and cold water passed through the coil C. The process of slow cooling being pushed far enough the connections of the pump are reversed and air is forced into the tank A with the result of compressing strongly the fluid insulation and forcing it into all the interstices. The pressure is preferably maintained until the mass is solidified. The application of the pressure is not only of great advantage because the insulation is forced into the interstices and prevented from shrinking away when cooling, but, in addition, any small gas-bubble which might remain in the condenser and would otherwise at ordinary atmospheric or smaller pressure be fatal to the instrument, is strongly compressed and the danger considerably lessened. The mass in the tank A being solidified steam is again turned on the pipe C for a few minutes in order to soften the insulation on the periphery and allow the vessel B to be lifted out of the tank, whereupon the condenser is taken out of the vessel and the superfluous insulation cut off. In the same manner primary and secondary coils are treated. As insulating material I have found best to use a mixture of

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beeswax and paraffine of low melting point, about half of each being taken. This gives a tough mass which does not shrink away much from the metal upon cooling. Condensers and coils manufactured in this manner will withstand incredible pressures. Very often in adjusting the primary discharge circuit it may happen that sparks of 3/8 or 1/2 inch dart across the condenser terminals, and yet it will not break down, although the dielectric is no more than a few thousandth of an inch in thickness. I have been unable to detect any increase of temperature whatever in the condenser after long working.

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To enable the secondary coils to withstand the effect of the enormous pressures producible with these instruments I have recognized it as necessary to build them on the general plan illustrated in fig. 11. The diagram shows two flat spirally wound coils, S_1, S_2, which are connected with their outer ends to a contact plate p in the proper direction so as to form in reality one single secondary coil, the terminals of which are respectively at the centres of the two wooden spools upon which the two parts of the coil are wound. These spools are held together by a cylinder of thin fibre sheet ff, which is sufficiently strong to insure solidity and perforated in order to allow the melted wax to fill the hollow spaces when the coil is put through the insulating process before described. In the centres of the spools are fastened threaded brass bushings bb to which the free ends of the secondary coils S1 S2 are connected and into which can be screwed brass pie-

ces ss. The latter are fastened to the ends of the hollow plugs of hard rubber rr, through which pass flexible wires ww, very heavily insulated with gutta-percha which serve to connect the secondary high potential ends to the discharge rods supported on the top of the instrument (fig.9). It is advisable not to insulate the wires ww with soft rubber, for this kind of insulation is soon destroyed by the ozone generated at their surface in consequence of the streamers which will form even if the rubber be very thick. The thickness of the insulation between the superimposed layers of secondaries is practically determined from an approximate estimate of the difference of potential between adjacent layers. Originally I have used heavily insulated wires with from two to four braids, but presently I am using ordinary magnet wire, which, in manufacturing the coil, is wound together with a string of a thickness equal to that of the wire. This is a convenient mode of insulating, not requiring specially prepared wire and secures excellent results. The middle of the secondary circuit or common joint of the two coils is connected to the ground, or to the mains, and this generally through the primary discharge circuit, the small contact plate or spring p serving to establish the connection, upon the secondary spools being inserted in the primary coil.

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The length of each of the secondary coils is so determined that it is somewhat less or equal to a quarter of the wave length of the electro-magnetic disturbance produced in the secondary circuit based, of course, on the practical estimate of the

speed of propagation of the disturbance through this circuit. It is obviously understood that the length of the secondary circuit is made to approximate more or less a quarter of the wave length, according to how much allowance is made for the capacity of the circuit under normal working conditions. In the ordinary uses of the instrument as laboratory appliance chiefly for the production of qualitative effects of high tension discharges little allowance is generally made for the capacity of the terminals, but if the apparatus is designed, for instance, for generating a large quantity of streamers between plates of great surface, or for charging condansers from the secondary or for such uses, then the length of the secondary wire is made much smaller and advantageously an even fraction of a quarter of that wave length which is obtained without any allowance for capacity other than that possessed by the coil. Finally, if secondary currents of comparatively low tension are desired the coil is constructed preferably of one single spool and of only few layers all in close proximity to the primary, so as to increase the mutual induction co-efficient and reduce the resonant rise of potential as much as possible. The closure of the magnetic circuit by oxygen at ordinary or high pressure, while of little effect with low frequency currents, is of a remarkable influence with currents of these unusual frequencies, expecially when the conditions are favorable for the occurrence of resonant phenomena. and I am anticipating practical uses of oxygen in this connection.

A secondary coil constructed in the manner illustrated

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in fig. 11 has many important advantages, the chief ones being the safety in handling and the facility it affords for obtaining potentials far beyond those producible if the ordinary methods of construction are followed. In order to convey an idea of the pressures obtainable even with so small an instrument as the one described, a photograph of the same in action with two loops of cotton covered wire attached to the discharge rods, is added (fig.12). The outer wire loop was in the experiment only 22 inches in diameter to enable it being properly shown in the print, but could have been much larger, since two such parallel wires 15 feet long may be stretched from the secondary terminals of the instrument and practically the whole space between them, four inches wide, is seen in the dark covered with fine luminous streamers, that is, a surface of 5 square feet, and yet the energy taken from the supply circuit during the performance is less than 35 watts. To produce with an ordinary transformer such a quantity of these streamers, which may be needed for the manufacture of ozone or similar purposes, would require a considerably greater amount of energy and a more costly apparatus.

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These extreme differences of potential obtainable by the use of the principle here involved are the result of the enormous suddenness or rate of change of the primary current impulses. In the ordinary method of varying the strength of the primary current either by alternating the same or breaking the conducting path we are limited to the comparatively insignificant rate of change pro-

ducible by means of a high frequency alternator or rapid break, but by the use of the condenser discharges there is practically no limit to the suddenness of the impulses, and any potentials and spark-lengths desired can be readily obtained. So, for instance, I have been able to produce, by applying the principle in a peculiar manner, immense electrical pressures, the theoretical maximum value of which can be measured only in many millions of volts, causing showers or continuous streams of thick, thundering sparks to dart out into space to a distance of eight or nine feet from an insulated wire, which behave sometimes like veritable lightening bolts and have afforded to the few who have witnessed them during the last two or three years in my laboratory a spectacle not easily forgotten. Nor is it at all difficult to increase, in a large hall or open space, many times the potential and sparking distance by the employment of such means and methods.

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Although in these oscillators the great suddenness of change in the strength of the currents depends chiefly on the electrical constants of the circuits, some advantages of minor but practical importance may be secured by a proper construction of the devices, used as convenient, though not indispensable, accessories of the system for the purpose of arbitrarily making and breaking the circuits. Accordingly, I have devoted considerable time to their study and perfection, and in connection with the typical arrangements of the circuits illustrated in figures 1, 3, 4 and 5,

I have dwelt in my earlier writings on this subject on a variety of such circuit interrupters in vacuum, air and other fluids at low or great pressures.

It has been known long ago, since the investigations of Poggendorff, that, when the vibrator or break of an induction coil was inclosed in an exhausted vessel, the interruption of the currents was effected with greater suddenness, the vacuous space acting in a certain measure like a condenser, connected, as usual, around the break. My experiments with several kinds of such circuit breakers have led me to recognize that the vacuous space is not exactly the equivalent of a condenser, but rather of an absorbent, the increased suddenness being simply due to the rapid carrying away of the volatilized material forming the arc, and therefore being dependent on the velocity with which the disintegrated matter is carried away and also on the amount of the latter. Thus, with very hard platinum-iridium contacts and small currents there is little difference, but with soft platinum points and heavy currents the influence of the vacuum is well noticeable, while, with mercury or in general easily volatilizable conductors, the difference is very great. The size of the exhausted vessel is also of some consequence, the break gaining in suddenness when the vessel is larger. Looking at Poggendorff's observations in this light it appeared clear to me that only a small velocity of the particles composing the arc can be obtained, since the effective pressure, at

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least with low frequency impulses depending on mechanical means and currents of limited strength which can be passed through the contacts without quickly destroying them, is necessarily only a minute fraction of the atmosphere, being, besides, very materially reduced by the oppositely acting attraction of the parallel current elements of the arc. Pursuing further this train of reasoning it seemed likewise evident that, if an insulating fluid be forced mechanically between the contact points with such velocity that the particles composing the arc were carried away quicker than it was possible with a small pressure producible in the gaseous matter in vacuum, the suddenness of disruption would be increased. This conclusion was borne out by my experiments in which I found that a fluid insulator, such as oil or alcohol, forced through the gap with even moderate velocity, increased very greatly the maximum rate of change of the primary current, and the length of secondary wire necessary for a certain spark length was in some instances reduced to 25 per cent of that usually required. The length of the secondary was still further reduced by the use of insulating fluids under great pressure. As regards the suddenness of the current impulse following the closing of the contacts, the introduction of an insulating space or film of greater dielectric strength than that of the air at ordinary pressure, though producing a distinct effect, is of small consequence when the interrupter in its operation actually breaks the arc, since the electro-motive force of a battery or municipal supply

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circuit is generally insufficient to break down an insulating film of even so small a thickness as one thousandth of an inch.

The continued effort to perfect the various automatic contrivances for controlling the supply current has clearly brought out their mechanical limitations and the idea of utilizing the discharges of the condenser as a means for producing, independently of such mechanical devices, the sudden variations of the current, which are needed for many purposes in the arts, appears evermore a happy and timely solution. In this novel process a function of only minor importance is assigned to the mechanical means, namely, that of merely starting periodically the vibration of the electro-magnetic system, and they have no other requirements to fulfill beyond those of reliability in operation and durability, features which are left to the skill of the mechanic and which, in a fair measure, it was not difficult to attain in a number of types.

Considering, then, that the rate of change of the discharge or primary current in these instruments is made to depend chiefly on the physical constants of the circuit through which the condenser discharges, it is evidently of utmost importance to construct properly the latter circuit, and in the investigations which were carried on with this object in view, several noteworthy observations have been made.

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First of all, one draws the obvious conclusion that, in as much as the primary coil in a transformer of this kind consists usually of very few turns of copper ribbon of inappreciable re-

sistance, the insulation between the turns should not require much care. But practical experience soon convinces him of his error, for, very often it happens that, owing to an exceptional resonant rise, the difference of potential between adjacent turns becomes so great as to rupture even a very good ordinary insulation. For this reason it was found necessary to treat the primary coils likewise in the manner described, thus securing the additional advantage of stiffness, which results from the expansion of the metal sheets and thickening of the insulating layers during the heating in vacuum and subsequent contraction of the metal in cooling to the normal temperature after the insulation has solidified.

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Next the experimenter is surprised when realizing the importance of the proper adjustment of the length of the primary coil and its connections. He is naturally prepared to find that, since the discharge circuit is of small length, the introduction in this circuit of a very small inductance or frictional resistance would produce an appreciable difference in the result obtained as, for instance, in the spark length of the secondary coil. But he certainly does not expect to observe that sometimes as little as a quarter of an inch of conductor more or less would be of a telling effect. To illustrate: It is quite easy to produce with this kind of apparatus a spark of several feet in length, and by merely taking off or adding to the primary an inch of thick copper wire reduce the spark-length to one half. Observations of this kind impress the

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experimenter with the importance of close adjustment of the circuits and accurate determination of their constants. His attention is forcibly attracted to the advantages of reducing as much as it is practicable the self-induction and resistance of the discharge circuit, the former with the object of securing the quickest possible vibration, the latter chiefly for reasons of economy. He also recognizes the necessity of bringing down to the minimum the length and resistance of all connecting wires. A well constructed discharge circuit in a small instrument, such as the one described, should have no more than five percent of inactive conductor, its resistance should be negligible and the self-induction should be no more than a few hundred centimeters. I have found it almost imperative to use thin copper ribbon in the construction of the primary coils, and with these an observation, which is the most curious of all, has been made. It occurs, namely, that, under certain conditions, the primary coil gets perceptibly cooler by continued working. For a long time this result appeared doubtful, but finally it was positively ascertained and ascribed to an exaggerated Thomson effect, owing to which heat is carried from the primary copper ribbon to the tin foil of the condenser.

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It might not appear quite clear at first why the primary discharge circuit is so sensitive to variations of length, for a circuit of any length might be connected to the condenser and, pro-

vided that the relation between resistance, capacity and self-induction is such as to satisfy the condition laid down by Lord Kelvin, oscillatory discharge will take place. But it must be remembered that the velocity of propagation of the disturbance in the circuit depends on these quantities, and that the best result is attained when the velocity is such that a stationary wave is formed with a single node which is located generally, but not always, at a point of the discharge circuit or conductor equi-distant from the opposite condenser coatings. Under such conditions the maximum effective pressure at the terminals of the condenser is obtained. But this state of things is only possible when the speed of the propagation through the discharge circuit is such that this circuit is traversed by the disturbance exactly in the time interval needed to complete half of one vibration. Now, since the speed is extreme and the length of the circuit very small, entirely insignificant variations of the length may often produce astonishing changes in the performance of the apparatus. These statements, of course, should not be construed as generally applicable, for they refer only to such cases in which the vibration in the discharge circuit, started by one operation of the circuit controller, does not die out before the succeeding operation of the controller. This may be made clear by a mechanical analogue. Suppose a weighted spring is clamped in a vise and a sudden blow is struck which sets the spring vibrating.

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Let the vibrations die out and let another blow be delivered. The spring will vibrate again as before, and it matters little what weight is attached to the spring, what the elasticity of the latter or, in general, what its period of vibration, and at what intervals the blows are delivered, the process of conversion of the energy of the blows into the energy of the vibrations will be effected with equal economy, except for secondary causes, immaterial for the present consideration. Exactly so is it with the electro-magnetic system, and in the early stages of development and practical adaptation of the prindple underlying the instruments described, I have employed condensers, either ordinary or electrolytic, of very large capacity and have caused them to discharge at comparatively long intervals through a primary circuit of negligible self-induction and resistance, thus producing current impulses which would sometimes reach, at least theoretically, maximum values of as much as 100.000 amperes. A high maximum rate of change in the primary current was thus producible, but, nevertheless, the average rate of change was still small. Considering again the mechanical analogue before mentioned a valuable lesson is at once derived. Looking upon the weighted spring as an appliance for converting energy, both economy and output demand that the vibration of the spring should persist as long as possible and that the blows should be struck as often as it is practicable. To satisfy this twofold requirement the blows must of necessity be delivered while the

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spring is still vibrating, and now it becomes most important to properly time the blows. Similarly again, in the electro-magnetic system the circuit controller must operate at definite intervals of time in order to secure the most vigorous vibration with the least supply of energy. In the construction of practical instruments the number of the fundamental current impulses is arbitrarily adopted, the condenser, being prepared by a special process, cannot be adjusted without great inconvenience, and the size and to a certain extent also the turns of the primary coil are likewise determined beforehand from practical considerations. Furthermore, it is desirable, for reasons of economy, not to resort to an otherwise convenient method of adjustment, which would be to insert a variable self-induction in series with the primary coil. These conditions render more difficult the exact adjustment of the various quantities, and I have sometimes found it of advantage to adopt one or other plan, such as will readily suggest themselves. For example, I have used an additional coil wound upon the primary and connected in parallel to the same, or I have completed the adjustments by determining properly the self-induction and capacity of the secondary coil.

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In order to facilitate the observation and also to enable the exact determination of the oscillations of electro-magnetic systems as well as of the vibrations or revolutions of mechanical devices, such as the circuit controller used in connection, it was recognized as indispensable, in the course of these investigations

to construct a proper apparatus for such purposes. I determined from the outset to avail myself of what is known as visual synchronism. In this scheme usually a disk or cylinder with marks or divisions, which is rotated with uniform velocity, is illuminated by a periodically varying or intermittent source of light, the divisions appearing stationary in space when the revolutions of the disk are synchronous with the variations in intensity or intermittences of the light-giving source. The chief virtue of such a method evidently resides in the uniformity of the velocity of rotation or eventually in the constancy of the period of the vibration produced. Having been early confronted with the problem of rotating a body with rigorously uniform velocity, which is required in many instances, or with the similar problem of producing a vibration of constant period, I have devoted some energy to the study of this subject, and in the course of time several solutions, more or less practical and satisfactory, have presented themselves.

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One of these, for instance, was to produce by means of compressed air or steam, the vibration of a freely movable plunger to which was rigidly connected a coil or core of an electric generator. By the reciprocating motion of the plunger alternating currents were generated which were passed through a condenser or else through the primary of a transformer, in which case the secondary coil of the latter was joined to the terminals of the condenser. Care being taken that the air or steam pressure was applied

only during a short interval of time when the plunger was passing through the center of vibration, and the oscillations of the electro-magnetic system, composed of the condenser and generating coil, being properly determined so that fundamental resonance took place, it was found that, under such conditions, the electro-magnetic system entirely governed the vibrations of the plunger and that the variations of the applied fluid pressure, while capable of producing changes in the amplitude, were within very wide limits without any appreciable effect on the period of vibration of the mechanical system, the currents generated being therefore of rigorously constant period. The currents thus obtained were then utilized in a number of ways to produce uniform rotation.

Another way to reach the same result and in a more practical manner was to generate currents of differing phase by a steam engine of special design, in which the reciprocating motion of the work performing plungers and attached magnetic cores or coils was controlled by a freely oscillating slide valve, the period of which was maintained constant by mechanical means or by the use of an electro-magnetic system, similarly as before. A synchronous alternating motor operated by the two or three phase currents thus generated rotated with a uniform velocity as to drive the wheel-work of a clock with fair accuracy.

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Still other solutions of the problems referred to I may mention which, though less satisfactory, have proved sometimes con-

venient and sufficient for many purposes. For example, a direct current motor with laminated fields or without any iron, was connected in series with a condenser through a commutator or interrupter fastened on the shaft of a light armature. This device was so constructed that it alternately closed and opened the terminals of the condenser, as usual in the instruments before described. The condenser terminals being closed, a strong current impulse passed through the motor, and upon the terminals being opened the discharge current of high tension rushed into the condenser. But the energy and duration of both of these succeeding current impulses, and consequently of all which passed through the motor, were made chiefly dependent on the self-induction of the motor coils and on the capacity of the condenser, and were therefore, with certain limits of variation of the applied electro-motive force, little dependent on the latter, and consequently a motor with a negligible friction loss, operated in this manner, turned with nearly uniform velocity. The latter was the more nearly constant the greater the controlling influence of the electro-magnetic system which, of course, was the most complete when the number of current impulses, the capacity and self-induction were so adjusted that fundamental resonance was maintained. As before stated, in most of these novel instruments described, such adjustments are observed and, whether provided with rotating interrupters or circuit controlling springs, they partake more or less of the virtue of the preceding principle.

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For this reason the contact springs in these instruments do not fall into harmonics, as they often do in ordinary induction coils operated from supply circuits, where the physical constants are generally such that similar adjustments are impracticable.

It should be remarked that, since a long time, it was known that a direct current motor, driven with currents interrupted at regular intervals, shows a marked tendency to maintaining a constant speed, but by the introduction of a condenser in the circuit and the careful adjustment of the quantities this tendency is very much increased, and for many purposes a sufficiently uniform velocity may be obtained in this manner. Instead of using interrupted currents for operating the motor it is practicable to rotate a separate coil, wound either on the same or on a second armature, and to pass the alternating currents generated in this coil through the condenser. It is important for the attainment of a satisfactory result in such cases to determine the constants so that the amound of energy stored in the condenser should be as large as possible.

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While a number of such arrangements were readily available, it was found, nevertheless, that they were inadequate to the many different requirements of the laboratory, and accordingly an instrument was devised which is illustrated in fig. 13 ab. It has proved itself to be so necessary and valuable an implement in experimental investigations, that its description here may afford

useful information. The cut is intended to show a substantial and carefully constructed clock-mechanism with the usual escapement e, gearwheels ggg, and a one second pendulum P. A small shaft s, carrying a disk D of large diameter, was geared to the clockwork through a pinion p of a proper number of teeth, such as to give to the shaft a velocity best suitable for observations. Now, in order to rotate the disk with a uniform velocity, some difficulties, well known to clockmakers, had to be overcome. The chief of these is due to the fact that the rotation of the shaft s, being controlled by the escapement e, which, at regular intervals, retards the the train of wheels ggg, is not effected with uniform, but periodically varying velocity, which may have all values from zero to a maximum, dependent on the driving weight W. Owing to this circumstance, when such a disk D of large diameter is rigidly geared to any kind of clockwork, it exerts, by reason of the great momentum which it necessarily acquires, a strong reaction upon the pendulum, altering the period of the same more or less, according to the momentum it possesses. This difficulty is known to exist, even in cases in which the step by step movement is practically done away with, as, for instance, in clockworks with centrifugal governors, or circular pendulums, in which slow oscillations are produced by the reaction of the moving mass upon the regulating mechanism. Some clockmakers have proposed an elastic connection between the

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body driven and the escapement, but this does not away radically with the difficulty. On the other hand when, in an attempt to overcome this disadvantage of the step by step movement, a quick acting escapement is used, whereby the periods of rest are reduced, and consequently the influence of the momentum of the rotated body upon the period of the pendulum, the result aimed at is but imperfectly attained and, besides, such an apparatus is less suitable for observation. Namely, it will be recognized as desirable for a number of reasons, that the disk D should be rotated normally either once or twice a second, according to whether a one or one half second pendulum is used. This being the case the experimenter can render himself easily an account of the constancy of the speed by observing a mark m on the disk and noting that it occupies a fixed position in space, relatively to that of the pendulum, in a convenient phase of vibration. Furthermore, the computation of the vibrations is rendered simpler and more convenient under such conditions.

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The problem clearly put was then, to rotate a body as the disk D, or other body, with any desired but uniform velocity in a way such, that the period of vibration of the pendulum was not much affected, even though the body rotated possessed considerable momentum. An entirely satisfactory solution of this problem was arrived at in the following manner. On the end of the shaft s, fig. 13 b, was fastened a light metal piece f in the shape of a cross,

carrying on two of its opposite sides pivoted pawls p, p_2, and on the other two light steel springs r, r_2, which pressed the pawls gently against the periphery of a washer w, which was provided with many very fine teeth or serrations cut sideways, similarly to those of escapement wheels. The washer w was arranged to turn very freely on the shaft s, and to it was fastened the disk D. The pawls p, p_2 were made with sharp edges to fit in the serrations of the washer w, and by these means the disk could rotate freely on the shaft s in the direction indicated by the arrows, but its rotation in the opposite direction was prevented by the pawls.

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The operation of the apparatus will now be at once understood. On the start the escapement wheel e, was released by unscrewing the thumb screw t and shifting the sleeve S on its rocking support. The pendulum was next started and when the escapement wheel had attained the normal velocity, the sleeve S was slipped back quickly and fastened, control of the escapement wheel being thus given to the pendulum. The wheelwork and also the shaft s now moved with periodically varying velocity, but the disk D continued to move uniformly, the pawls p, p_2 slipping on the periphery of the washer w during the periods when the revolution of the shaft s was retarded by the pendulum. When, however, after some time, owing to the very small but unavoidable friction loss in the air and bearings the speed of the disk would slowly diminish and fall below the maximum velocity which the shaft s was capable of imparting

to it, then the pawls would give it a slight impulse, and in this manner the disk was kept constantly at the maximum velocity. By each swing of the pendulum the disk would thus receive one impulse, and its velocity depended on the amount of energy imparted to it by each of the succeeding impulses. This amount of energy depended, of course, on the velocity of the shaft s during the period when the escapement wheel was free, and since this velocity was determined by the driving weight, the speed of the rotation of the disk could be varied within certain limits by adjusting the weight. It will be observed that, generally, the disk would rotate considerably faster than the shaft s, but it was easy to adjust the driving weight so that the disk rotated just once by one swing of the pendulum. In producing the rotation by these means the influence of the momentum of the disk upon the period of the pendulum is found negligible. This result, of course, could not be attained by connecting the disk rigidly with the shaft s, even if a quick acting escapement would be used, as before suggested. The uniformity of rotation secured in this way leaves, for all practical purposes at least, nothing to be desired. The apparatus might have been improved by supporting the disk on an independent bearing and, perhaps, also by rotating it horizontally in a jewelled support. But the friction loss was very small, since, by arresting the shaft s suddenly, the disk would generally rotate something like one hundred times or more before stopping, and such improvements were thought

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unnecessary. The vertical position was, however, chosen, because it was much more convenient for purposes of observation. In order to reduce the weight of the disk D as much as possible, a light frame, consisting of a circular rim with narrow spokes, was cut out of thin aluminum sheet, and black paper glued on the frame, all marks and divisions of the former being, of course, white. I found it convenient to draw concentric circles with a number of marks such that all vibrations within the range of the apparatus could be read off. In addition a segmental piece of hard rubber N, supported on a bar T and properly marked, was used to read fractions or, respectively, take corrections for any irregularity in the rotation during a prolonged period of time. Near the disk was placed a vacuum tube or, in its place, an adjustable spark gap 1, which was connected to the secondary of a small transformer, the primary of which was positively controlled by the mechanical or electro-magnetic system the vibrations of which were to be determined. In preparing a spring of the desired period of vibration for one of the instruments described, for instance, the spring was provisorily mounted on the instrument and the latter put in operation. The disk, intermittently illuminated by the discharges of the secondary coil, was released from the pendulum and rotated until synchronism was attained, the revolutions being computed by observing the white mark m. The constants of the spring were then modified after a

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simple calculation from the first result, and in the second trial, as a rule, the vibration was so close as to enable the use of the escapement, the adjustment then being completed, generally by altering the weight of the hammer on the spring until the marks on the disk, by the normal speed of rotation, appeared stationary in space.

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The apparatus described in fig. 13 will be found very convenient and time-saving in a great many lines of experimentation. By means of the same it is practicable to rotate a body of considerable weight with uniform and adjustable velocity, and it lends itself to the operation of circuit controllers, curve-tracers and all kinds of such devices. It will be found most useful in tracing current or electro-motive force curves and a variety of diagrams, and will afford material help in determining a number of physical quantities. But its most valuable use in the investigation of electrical vibrations is, perhaps, for the purpose of determining exactly the angular velocities of dynamos, particularly of alternators. Among the various quantities which, in alternate current experimentation and practice, one has to determine very frequently, there are some, which even in a laboratory or shop in the midst of the disturbances of a city or factory can be ascertained with sufficient precision, while there are others which can be only approximated, particularly if, as is very often the case, practical methods of measure must be resorted to. So, for example, the close measurement of resistances offers no difficulty, nor does that of

currents and electro-motive forces, although the degree of exactitude is necessarily smaller; but in determining capacities one is liable to make a considerable error, still a greater one in measuring inductances, and probably the greatest in estimating frequencies. In many places such crude devices as speed counters or tachymeters are still resorted to, and the experimenter is disappointed to realize that the accuracy of his long and painstaking tests is impaired because of his inability to determine exactly the frequency. To make matters worse, very often too, the latter is the largest and most important quantity. In view of these facts a description of the method adopted by me for the determination of angular velocities may be of some value.

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The devices commonly used are illustrated diagramatically in fig. 14, a and b. On the shaft S (fig. 14 a) of the generator is fastened a commutator or circuit controller C, provided with any suitable number of segments, eight being shown in this instance. Four of these, 1, 3, 5 and 7 serve to establish the connections of the circuits, while the intermediate ones, 2, 4, 6 and 8 are entirely insulated idle segments. Assuming the generator to be an alternate current machine, the terminals t, t_2 of the armature winding, or of any desired coil or part of the same, are led through the hollow shaft, as may be the case, and connected to the diametrically opposite segments 3 and 7, while the segments situated at right angles, that is 1 and 5, are connected together

through a wire w of inappreciable resistance. Two brushes b, b_1, supported in an ordinary holder allowing their being shifted in any position, are arranged to bear upon the periphery of the controller C. These brushes are connected to a circuit comprising a condenser c of proper capacity and a primary coil p, which has but a few turns of very small self-induction and resistance and is joined in series with the condenser.

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The operation of the devices is as in the instruments before referred to. When, with the rotation of the shaft S, the brushes b, b_1 are brought in contact with the segments 1 and 3, the condenser is charged to a potential which can be adjusted at will by shifting the brush holder. The condenser retains a certain charge until the brushes b, b_1 come to bear upon the connected segments 1 and 5, whereupon an oscillatory discharge through the primary p takes place with the result of inducing strong current impulses in the secondary s, which momentarily light up the vacuum tube or spark gap 1 placed in proximity of the disk D, which is rotated with uniform velocity, as before described. With the rotation of the circuit controller the brushes are again brought in contact with the segments 1 and 3, and the operations are repeated, at each complete revolution of the armature shaft a definite number of impulses being passed through the vacuum tube or spark gap. In the device illustrated there will be only two impulses for each revolution of the armature, but any greater number may be arranged for by

augmenting the number of the segments and connecting them in the same manner. It should be stated that the current impulses, which pass into the condenser whenever the brushes b, b_2 are on those segments which are connected to the armature coil, ordinarily produce no appreciable effect in the secondary s. This might be the case if the number of segments would be very large and would then be at once noted. The proper adjustment of the circuit through which the condenser discharges is, of course, preferable but not absolutely necessary.

When it is inconvenient to use the armature current, as illustrated in fig. 14 a, then the controller C is provided with two sliding rings r, r_2 (fig. 14 b), upon which are made to bear two additional brushes b_3 b_4. The latter are then connected to a direct current source, as the ordinary supply circuit, preferably through a self-induction coil, which serves to charge the condenser to a higher potential. The rings r, r_2 merely ~~xxxxxxxx~~ convey to the segments 1 and 3 the current for charging the condenser, otherwise nothing need be changed on the devices.

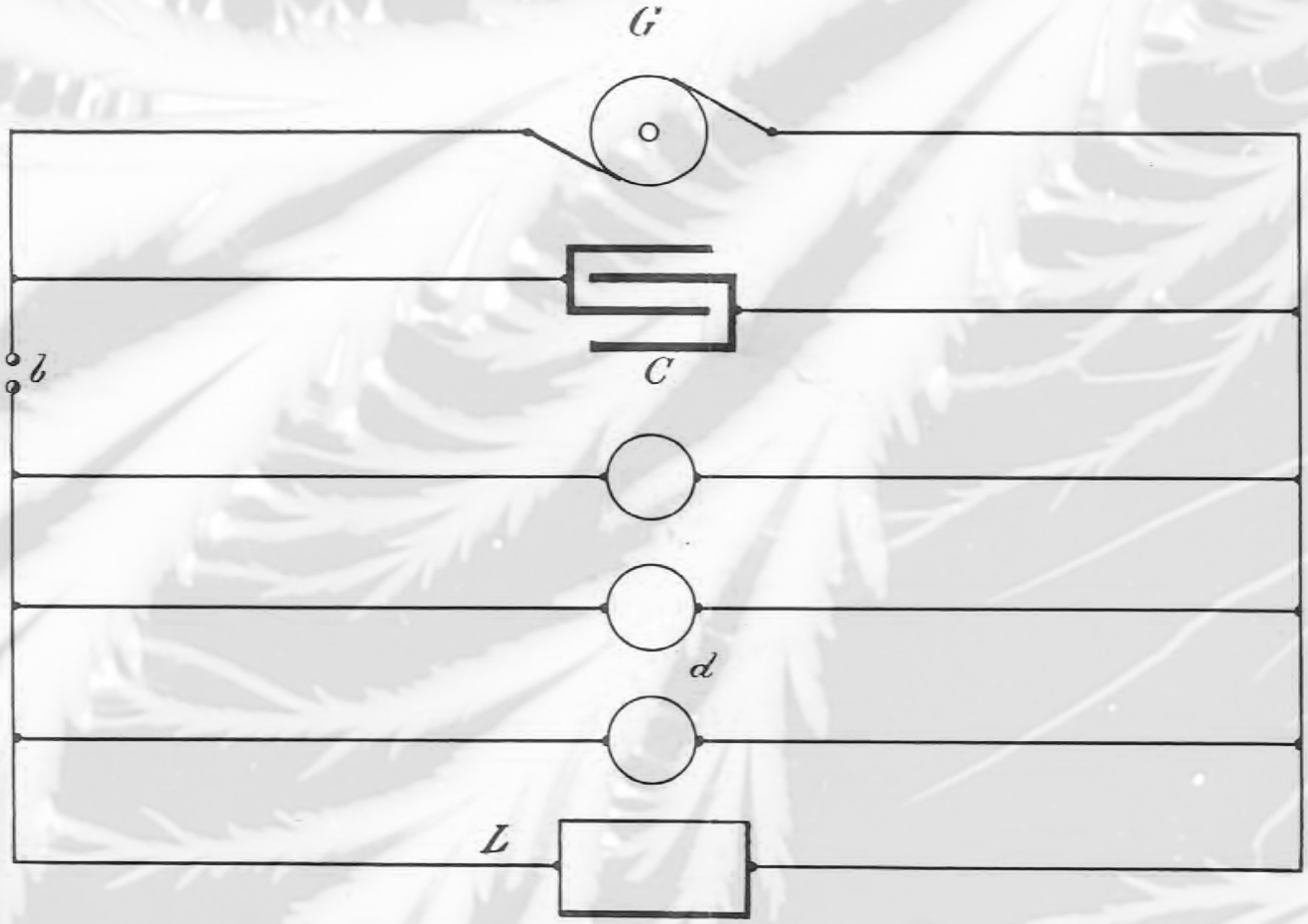
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The marks or divisions on the periphery of the disk D are suitably made so that by the normal speed of the generator they appear stationary in space. This being the case the speed may be at once and easily computed from the number of segments on the controller and that of divisions on the disk and from the speed of the latter. The frequency of the dynamo currents is then given by taking into consideration the number of poles.

In availing himself of this method the experimenter can

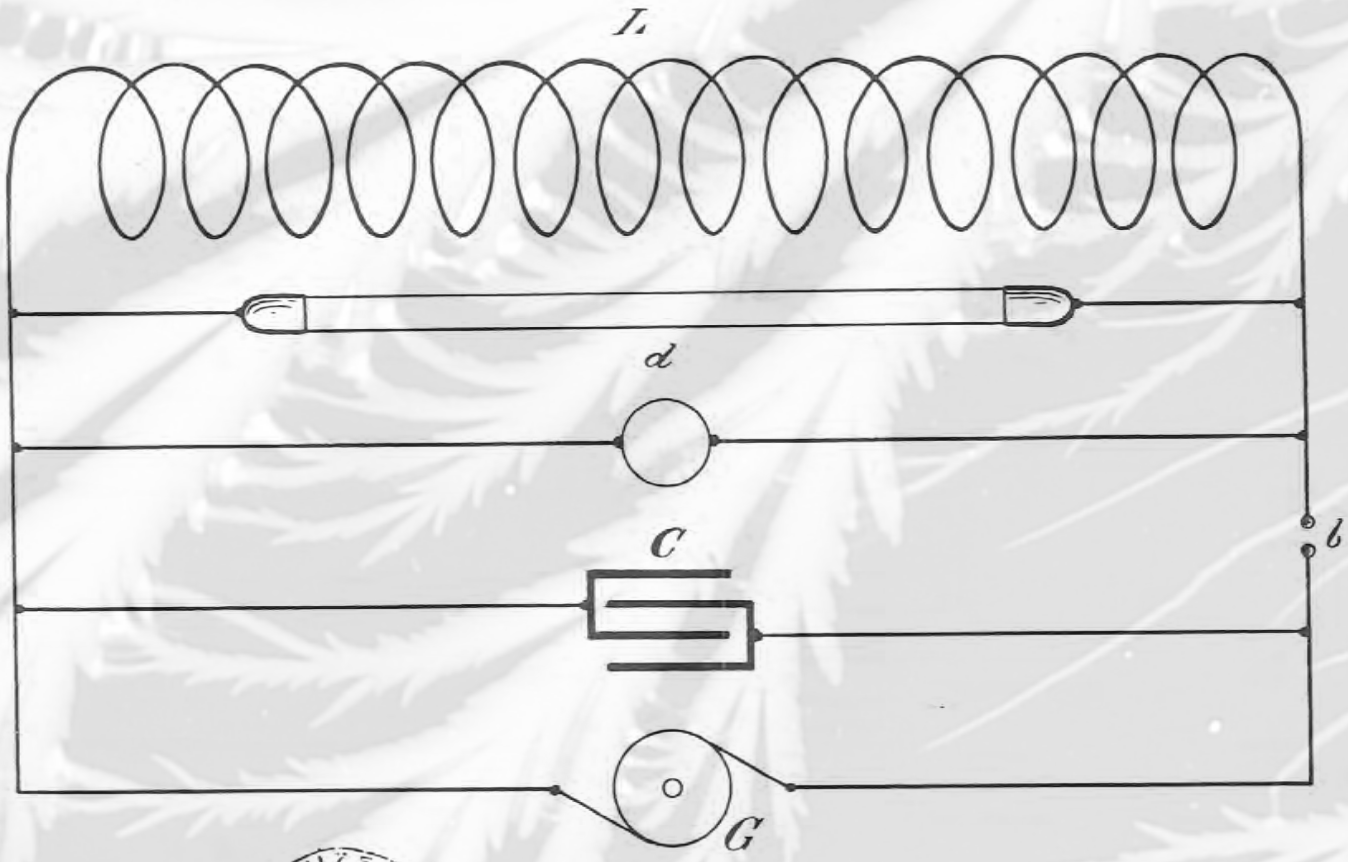
get the accurate value for the angular velocity, no matter how much the speed of the dynamo may vary, if he only takes the precaution to make his readings for electro-motive force, current, etc. at the instant the marks on the disk are stationary. Should the reading consume more time it is easy to take the correction for any variation by simply observing, with reference to a fixed line on the rubber piece N, the number of divisions which are to be added to, or deducted from, the speed of the disk.





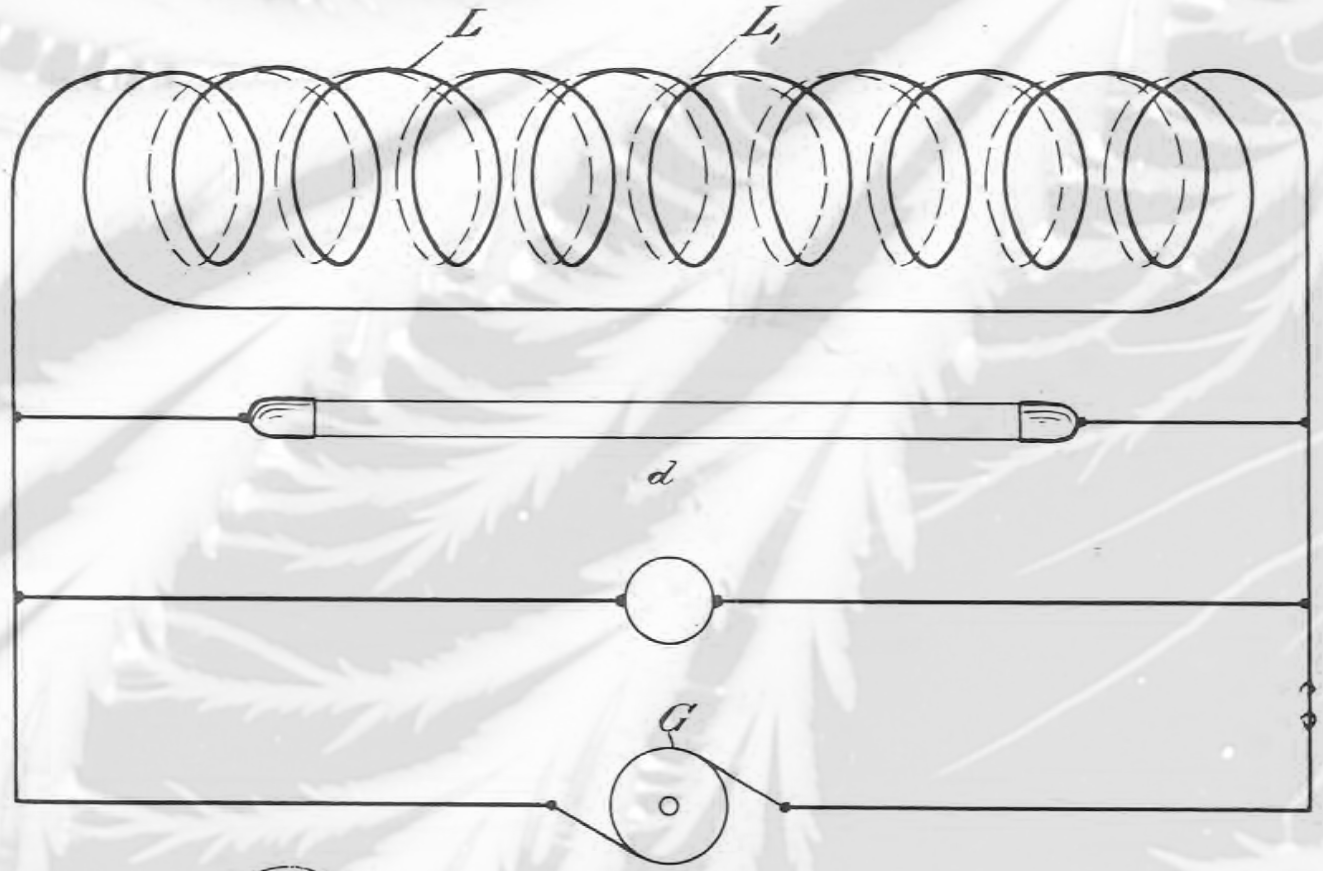
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Fig. 1.



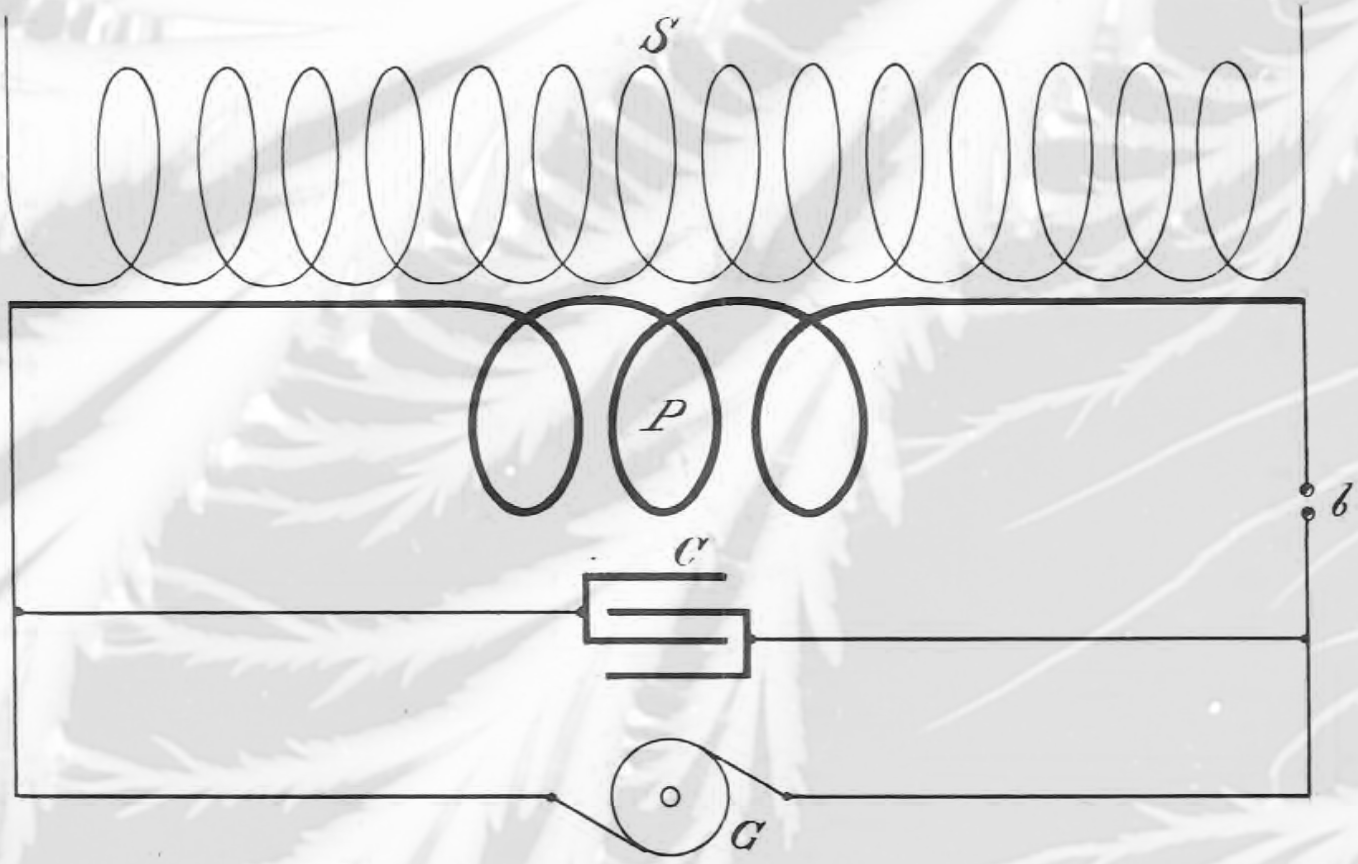
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Fig 3.



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Fig 4.



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Fig 5.

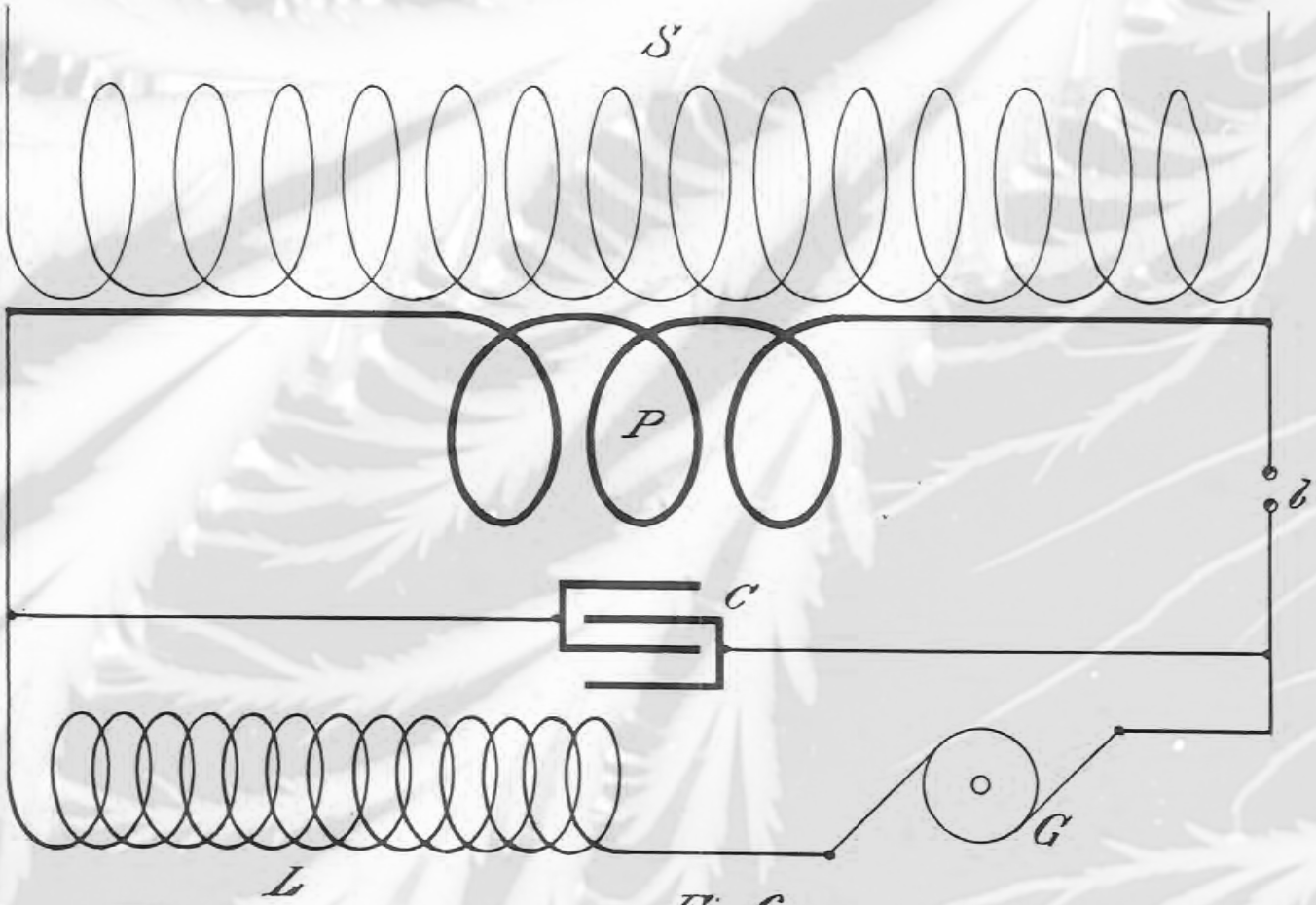
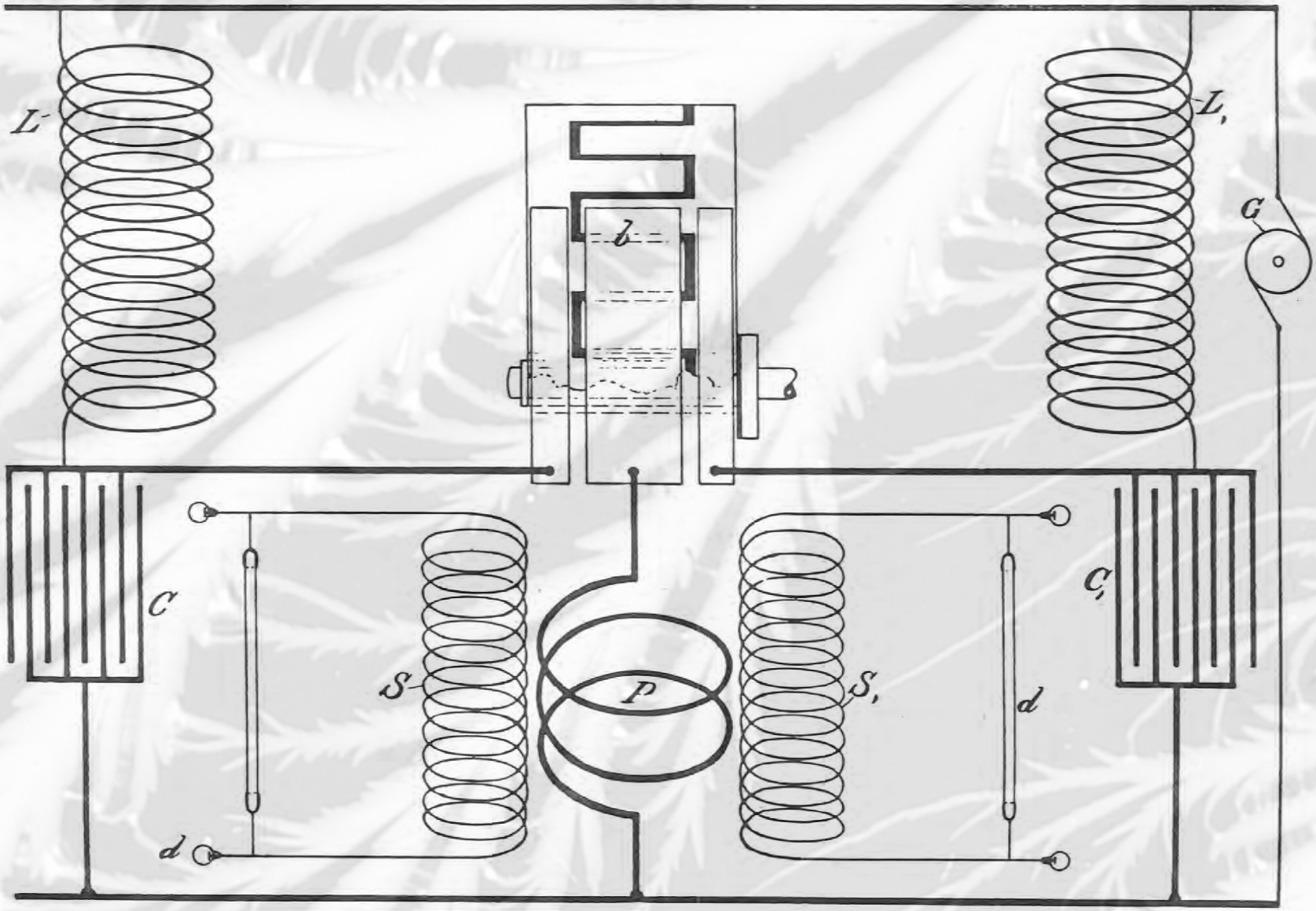


Fig 6.

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Fig 7.

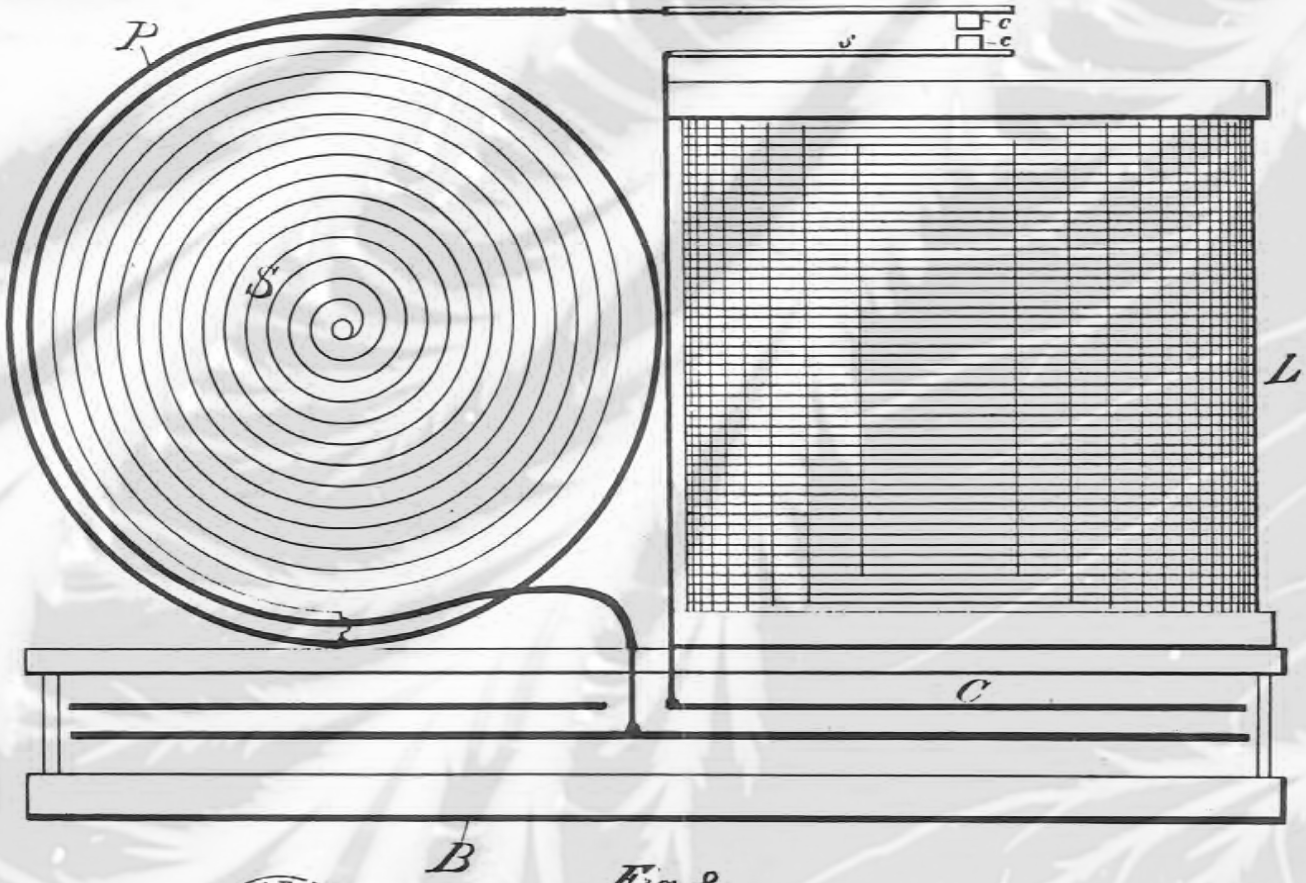


Fig 8.

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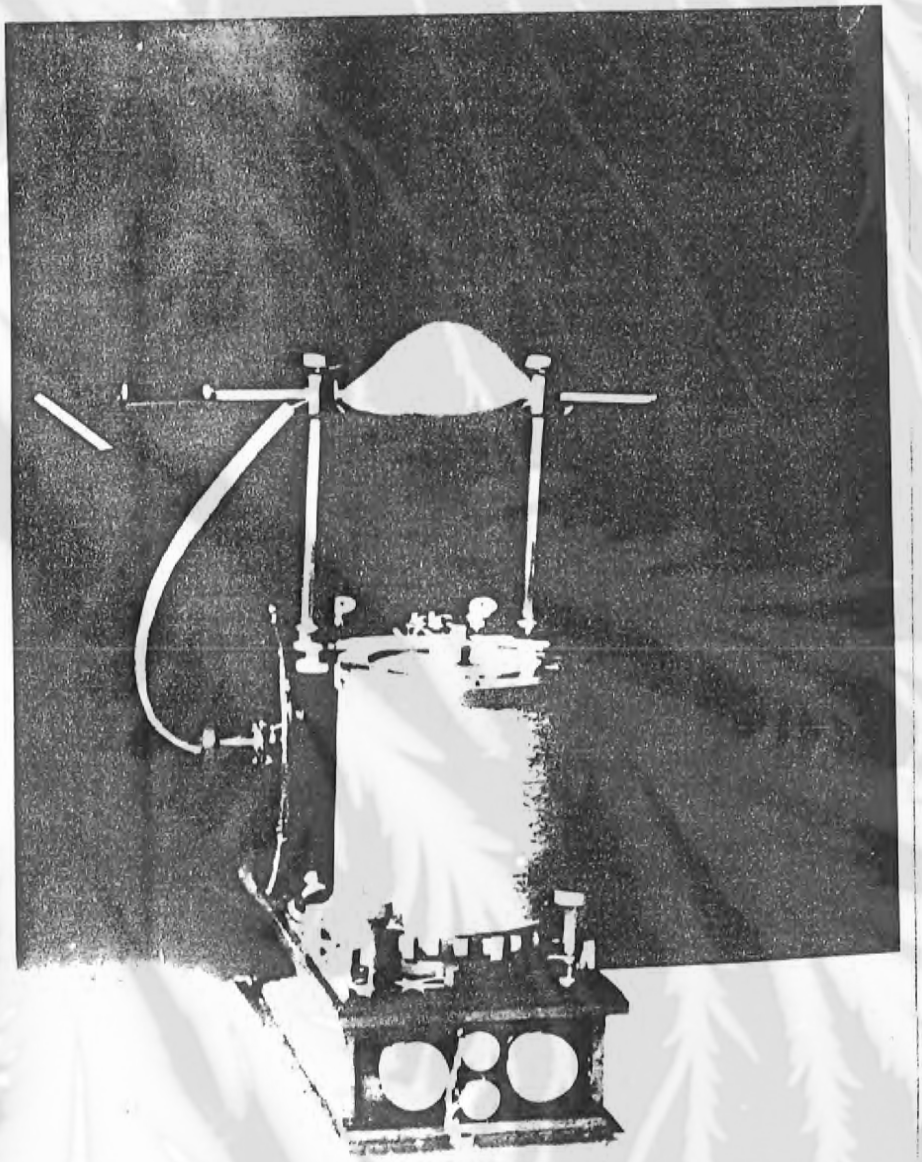


Fig. 9

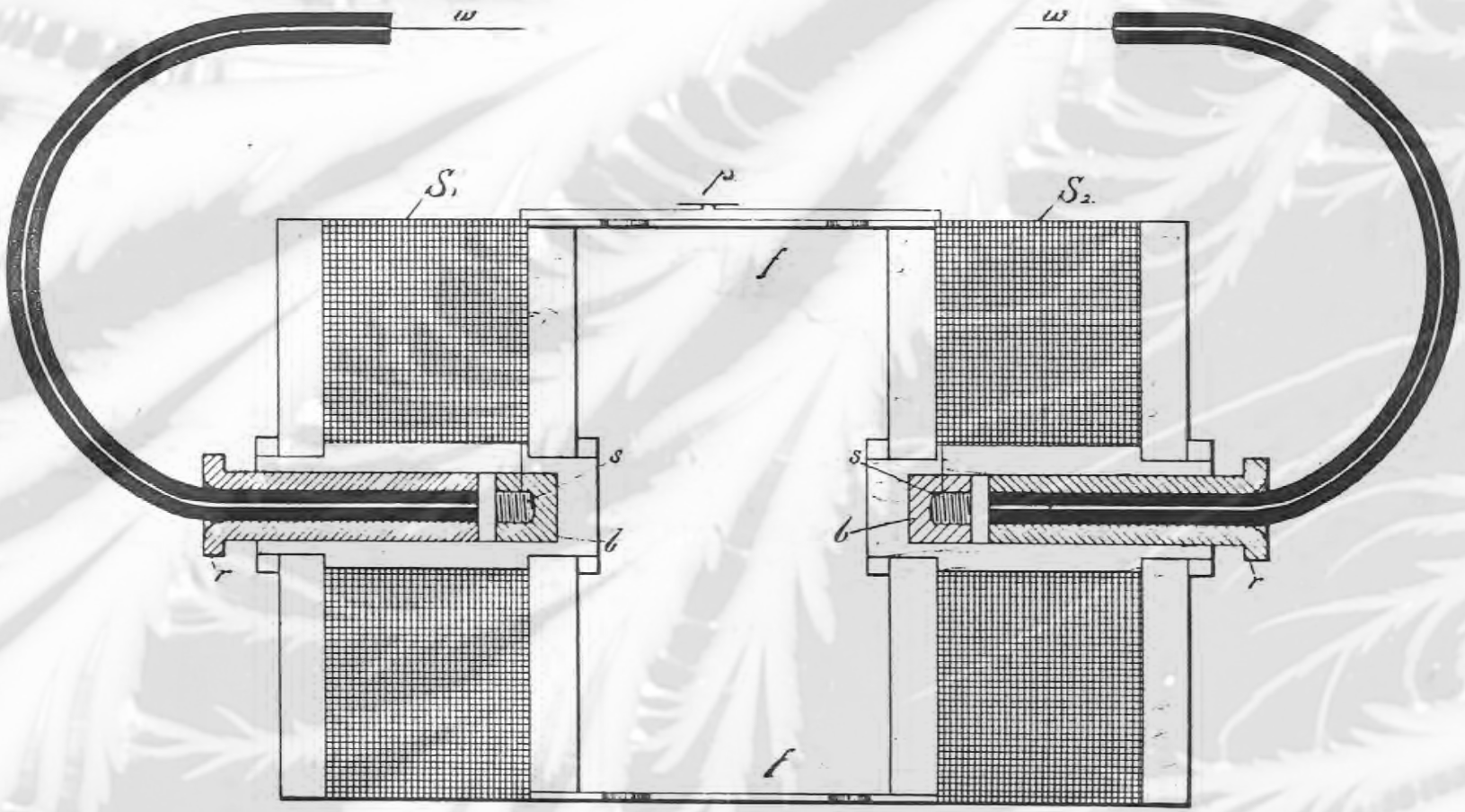


Fig. 11.

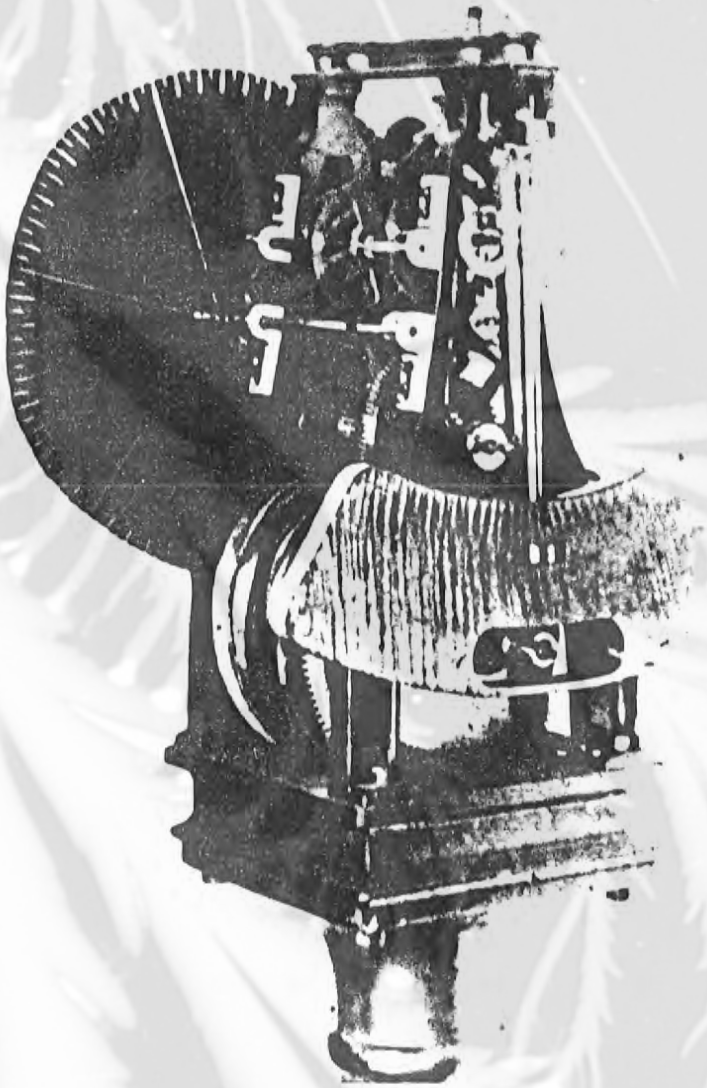
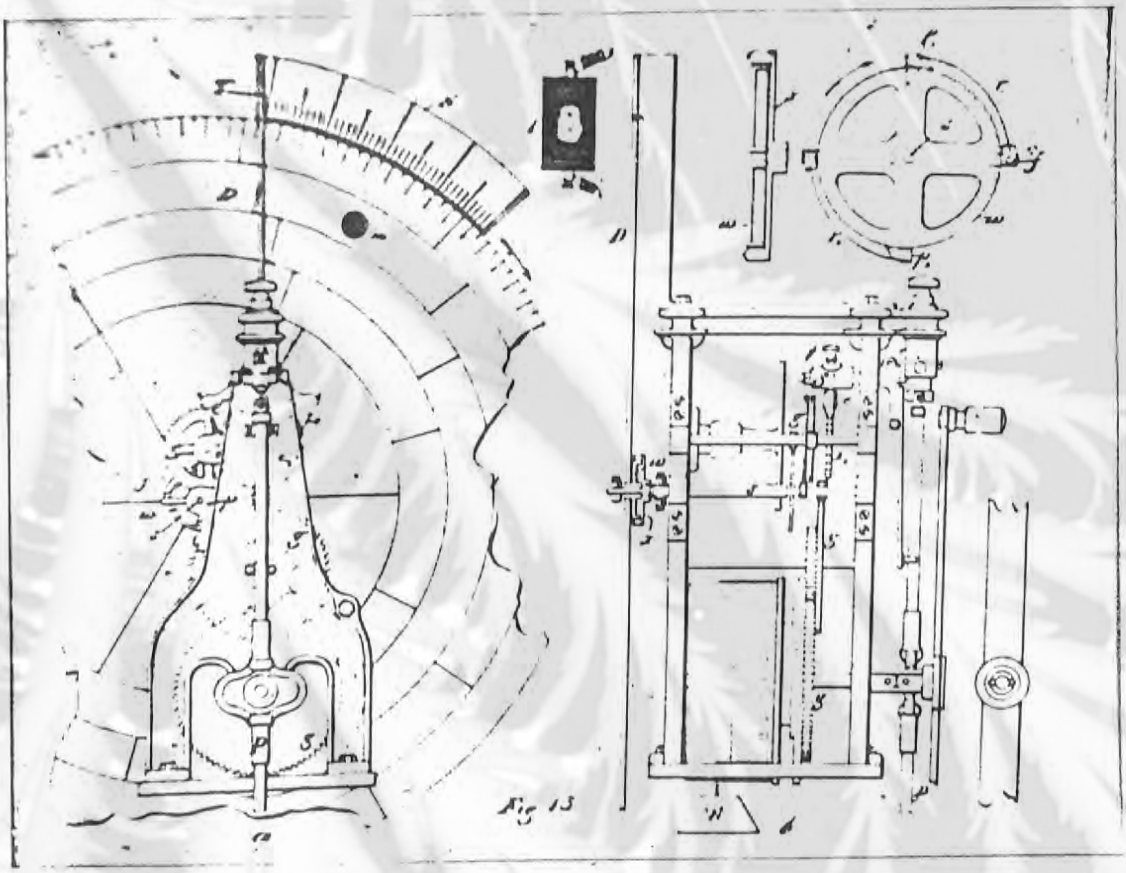


Fig. 12



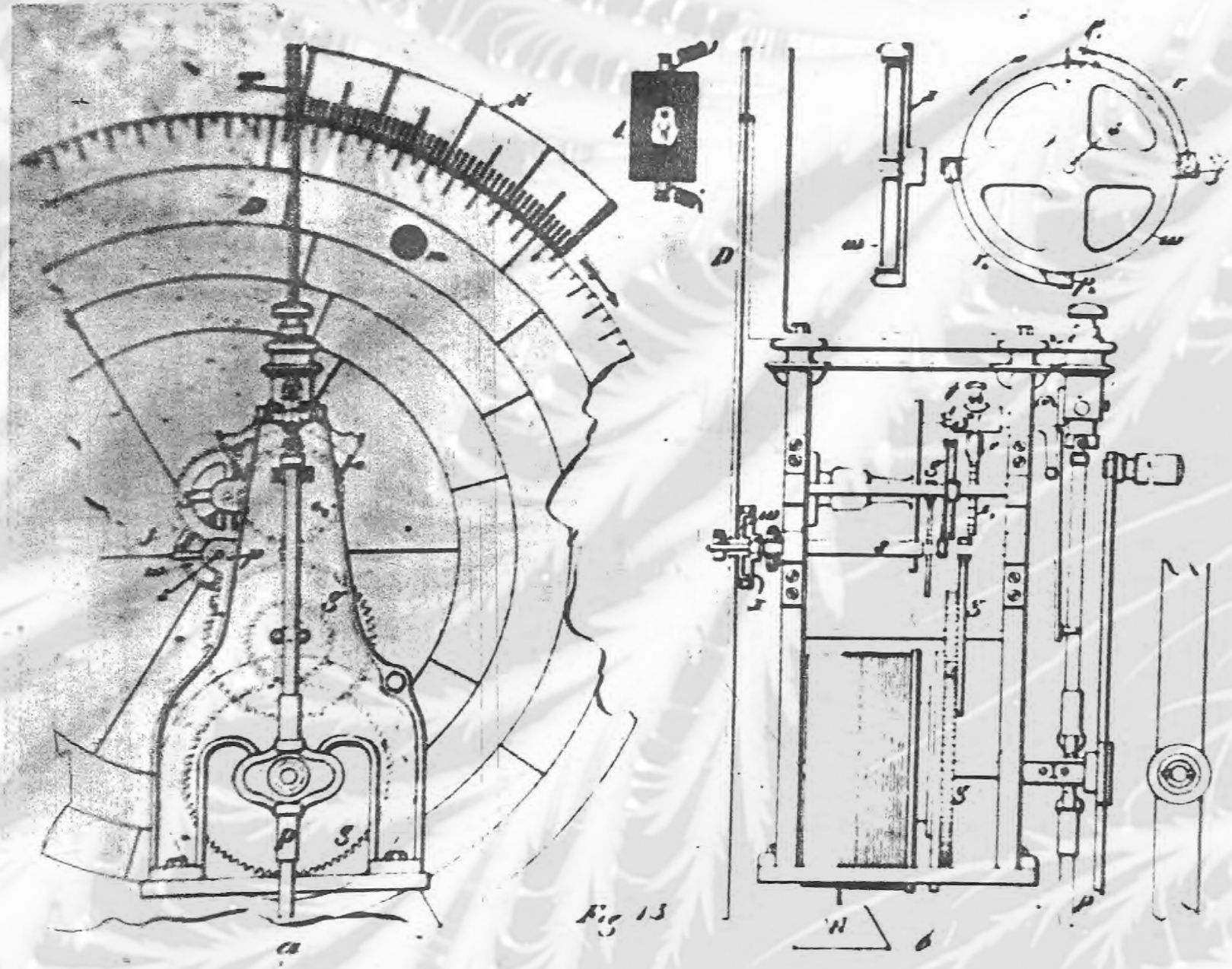
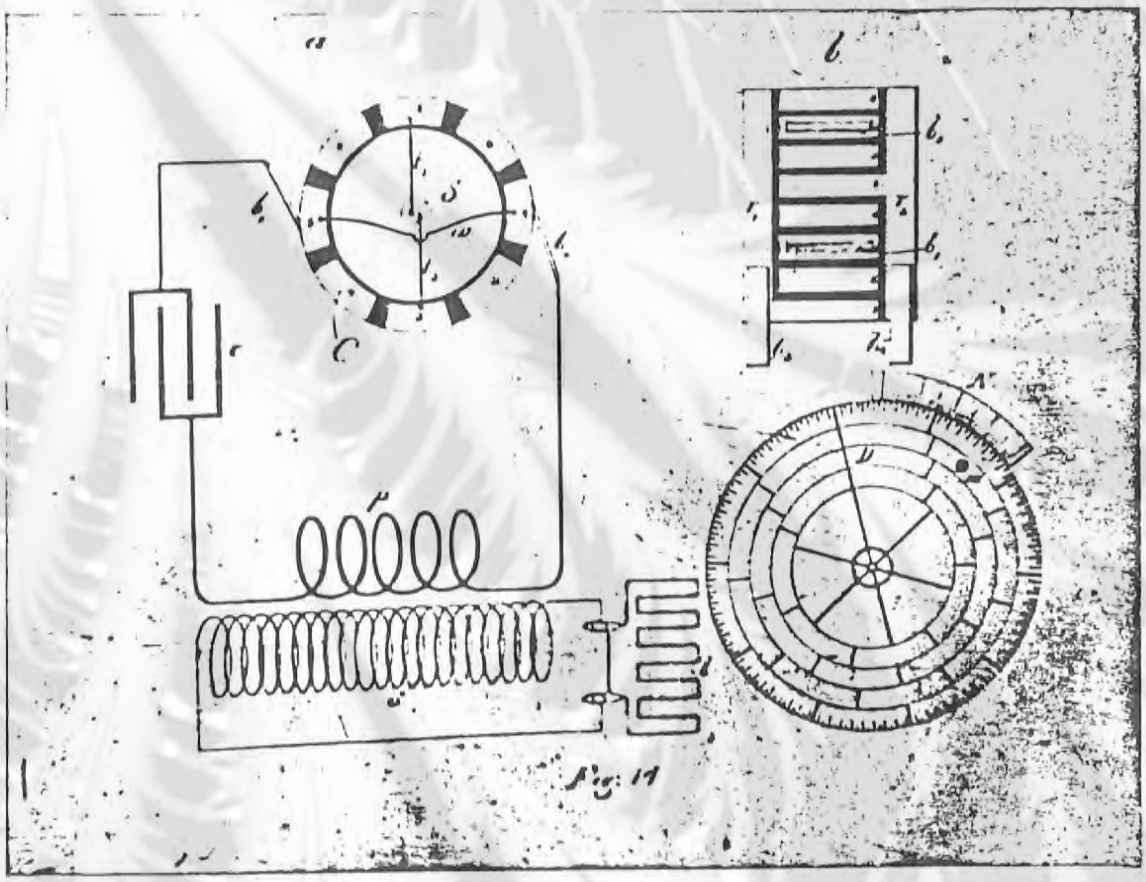


Fig 13


a
b
C
D
Fig. 11

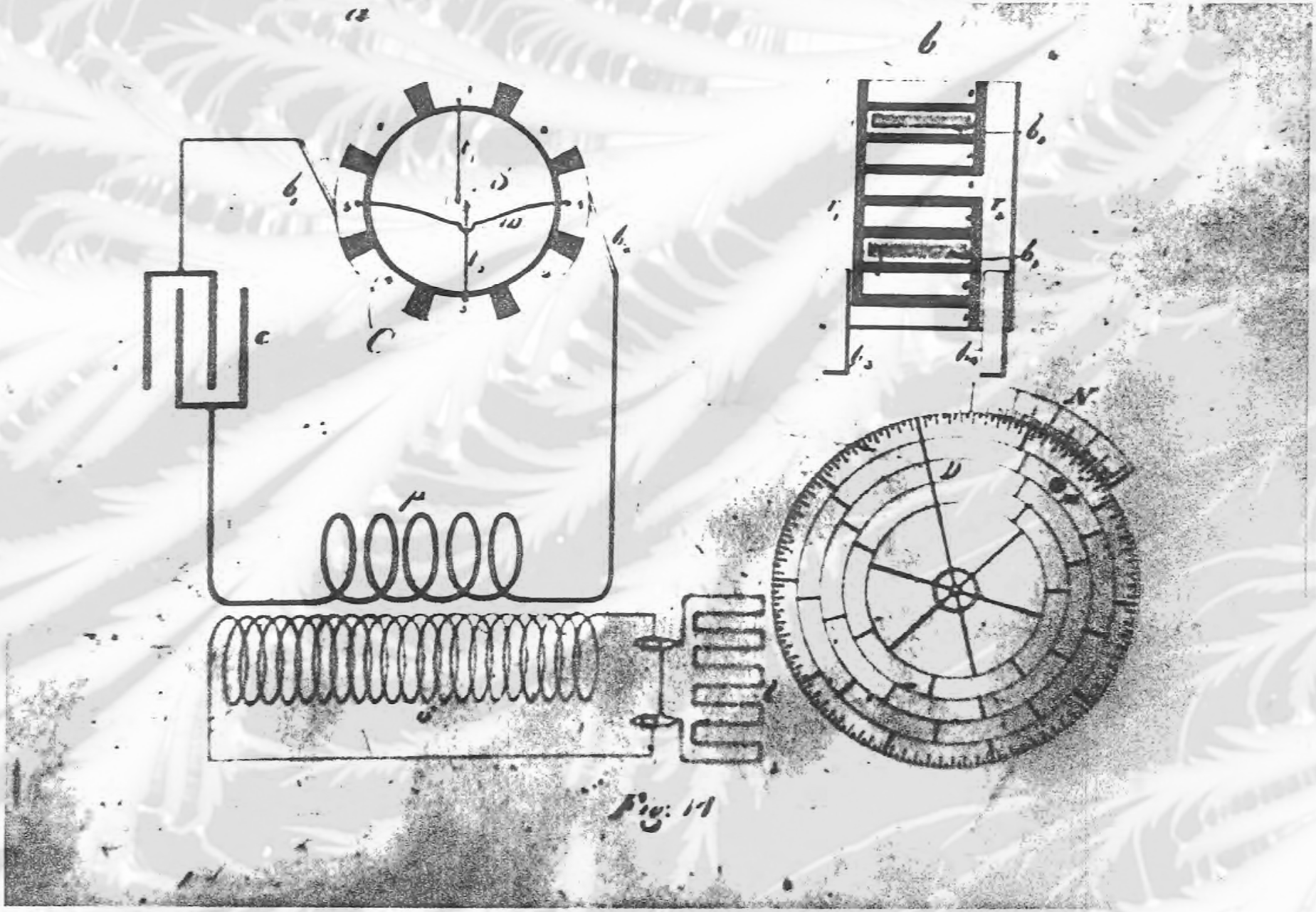


Fig: 11

Lecture before the New York Academy of Science, April 6, 1897.

Ladies & Gentlemen:-

You will still remember vividly, no doubt, the excitement which a year ago was caused by the announcement of the discoveries of Prof. Roentgen. Suddenly, without any preparation, Roentgen surprised the world with two wonderful results. He showed us how to take a photographic impression of an object invisible to the eye and, what seemed still more extraordinary, he enabled us, by the help of his luminous screen.- now known as the fluoroscope - to see, with our own eyes, the outlines of the object. We are living in an age of exceptional intellectual activity, and important advances are often recorded, but these were almost of the order of the telescope and microscope and <u>such</u> discoveries come no more than once or twice in a century. Scarcely can any one of us ~~hope~~ to again witness in his lifetime an event of so wide-spread a scientific and popular interest. The desire to see things which seem forever hidden from sight is more or less strongly developed in every human being, through all degrees of this sentiment, from the idle curiosity of the unenlightened to the absorbing desire for knowledge of the highly refined, and this in itself was sufficient to engage universal attention; but, apart from this, these discoveries brought promise of relief to numberless sufferers and stirred all over the world the fibres of humanity. It is hardly necessary for me to

tell you that the fever took hold of me also, but mine was a singular, grave case, and I have not recovered from its effects to this day. I hope you will pardon here a slight digression which I have a strong reason to make.

At the close of 1894, realizing the necessity of recovery from a straining task, on which I have been laboring for a number of years and which still commands my energies, it occurred to me to investigate the actinic action of phosphorescent bodies. The subject did not appear to have been studied, and I began the work at once, securing later, at the suggestion of some friends connected with the Century Magazine, the assistance of Messrs. Tonnelé & Co., artists' Photographers, of this City, then doing work for this Magazine. In these experiments I employed an improved apparatus for the production of powerful electrical vibrations, as well as one of my high frequency alternators of old design. A great variety of Crookes tubes, single-electrode globes and vacuum bulbs without external electrodes were experimented upon. A surprising fact was soon brought to light; namely, that the actinic power of the Crookes bulbs varied greatly and that some, which emitted a comparatively strong luminosity, hardly showed an effect, while others, of much smaller light-giving power, produced strong impressions. I wish to state here, in order to be clear, that my efforts were directed towards investigating such actions of true phosphorescent light, as furnished from bulbs without appreciable emission of heat,

and not so much those of incandescent vacuum tubes, although some photographs were likewise taken with these. As both the artists and myself were busy on other matters the plates in their ordinary holders were frequently put in some corner of the laboratory until a suitable opportunity for carrying on the experiments was found. During these investigations many plates gave a result, while many others failed, and on some of these both Mr. Alley, who then assisted me, and myself noted unaccountable marks and defects. Mr. Alley particularly found it extraordinary that, in spite of his care, many plates proved defective and unsuccessful. The taking of these photographic impressions by means of Crookes bulbs brought freshly to my mind the experiments of Lenard, some features of which, particularly the action on a sensitive plate, had fascinated me from the start, and I resolved to go over the ground covered by him with assistance and improved appliances. Just as my attention was arrested by this feature my laboratory with almost everything it contained was destroyed; and the few months following passed in intense activity which made me temporarily forget my projects. I had hardly finished the work of reconstruction and resumed the course of my ideas when the news of Roentgen's achievement reached me. Instantly the truth flashed upon my mind. I hurried to repeat his incompletely reported experiments, and there I beheld the wonder myself. Then -too late- I realized that my guiding spirit had again prompted me and that I had failed to comprehend his mysterious signs.

The statement of these facts might have been misinterpreted at the time of Prof. Roentgen's announcement, and I have kept silent, although I was unable to overcome entirely my feeling in the introductory lines of my first of a series of articles I wrote on this subject in the columns of the Electrical Review. Presently, however, I have no fear of a misunderstanding of my words, and I am recording my painful but stimulating experience solely to make some of those, who have lightly written about the history of this new art, more justly appreciate this new departure. I was quite well acquainted with the results of Lenard and naturally often thought of his beautiful and promising experiments, and yet the possibility of the plates being marked and spoiled by some action of the bulbs never presented itself to my mind. While some might see in this only an argument for my own short-sightedness, others, more kindly disposed towards me, will, with myself, consider it rather a demonstration of Goethe's great words, which I will not repeat in the text, but which say that, what Nature does not want to reveal to one's mind, one cannot force it from her with screws and levers.

But while I have failed to see what others in my place might have perceived, it was always since my conviction, which is now firmer than ever, that I have not been forsaken by the kind spirit who then communed with me, but that, on the contrary, he has further guided me and guided me right in the comprehension of the

marvellous
nature of these manifestations. Perhaps, in bringing to your attention some new facts which I have since discovered in addition to those already announced, I may induce, at least some of you, to interpret these phenomena as I do. For fear, though, that I might miss my chief object this evening, I must ask your kind indulgence to dwell in a few words on the novel appliances which are exhibited here for your inspection. When I trace their origin I find it clearly in my early recognition of the fact that an economical method of producing electrical vibrations of very high frequency was the key for the solution of a number of most important problems in science and industry. Insignificant as these machines may seem to you, they are nevertheless the result of labors extending through a number of years, and I can truthfully say that many times the difficulties which I have encountered in my endeavors to perfect them, have appeared to me so great as to almost deprive me of the courage to continue the work. When the experimenter has to spend several years of patient effort only to recognize that a mere microscopical cavity or air bubble in the essential parts of his apparatus is fatal to the attainment of the result sought for by him; when he has to find that his machine does not perform well because a wire he uses is a quarter of an inch too long or too short; when he notes that now a part of his apparatus when in action will grow colder in an apparently inexplicable way, and next that the

same part will get overheated, though to all appearance the conditions are unchanged; when he makes puzzling observations at every step and ordinary instruments and methods of measurement are not available, then his progress is necessarily slow and his energies are severely taxed. Finally, I am glad to say, I have triumphed over at least the chief obstacles, and nothing of any serious consequence stands now in the way of obtaining electrical oscillations of frequencies up to a few millions a second from ordinary supply circuits with simple and fairly economical appliances. What this means I need not discuss. It will be duly judged by those who have kept in touch with the development in this and allied fields. These machines you see are only a few of the types I have developed and as they stand here they are chiefly intended to replace the ordinary induction coil in its numerous uses.

As to the broad principle underlying these transformers or electrical oscillators, as they might be most properly called, it is simple enough and has been advanced by me some five or six years ago. A condenser is charged from a suitable source and is then in any convenient way discharged through a circuit containing, as it does here, the primary of the transformer. The first diagram here, fig 1, illustrates a generator (G), a condenser (C) and for charging and discharging the latter any kind of device (S) adapted to produce an intermittent break in the dielectric. The circuit containing the high or low tension devices through which the condenser discharges being properly adjusted, extremely rapid elec-

trical vibrations which, so far we know, are unattainable by any other means, result; and these set up by inductive action in any neighboring circuits similar vibrations which give rise to many curious phenomena. Having familiarized myself with these at the time when some laws governing them were not quite well understood, I have retained certain conceptions which I have then formed and which, though primitive, might stand even now in the light of our present advanced knowledge. I have likened a condenser to a reservoir (R) into which an incompressible fluid is (by means of a pump (P)) (as water (W)) supplied through a feed-pipe (F), as illustrated in the second diagram, fig. 2, the fluid representing (the pump, the generator and the feed pipe the connecting wire.) electricity. The reservoir has a movable bottom (B) held up by a spring (S) and opens (the ports (OO)) when the fluid has reached a certain height (in the vessel) and the pressure has become sufficient to overcome the elastic force of the spring. (To complete the model adjustable weights w, a screw s for altering the tension of the spring) With the giving away of the bottom the fluid in the reservoir acquires velocity and consequently momentum, which results in an increased pressure against the bottom, causing the latter to open wider, and more of the fluid rushes out than the feed-pipe can supply, whereupon the spring reasserts itself, closing again the ports, and the same process is repeated in more or less rapid succession. This opening and closing of the bottom may be likened to the making and breaking of the conducting path, the frictional resistance in this mechanical system to the ohmic resistance and, obviously, the inertia of the moving masses to the self induction of the electric

(and a valve v for regulating the flow of the fluid are provided)

circuit. Now it is evident that, in order to keep in action the mechanism without the employment of auxiliary means, the average rate of supply through the pipe must be inferior to the average rate of discharge through the bottom; for, if it be otherwise, the ports will simply remain open and no vibration will take place. The more nearly the average rate of supply equals the average rate of discharge the quicker will the bottom open and close; and it is furthermore clear from a consideration of simple mechanical principles that, if the fluid be supplied so fast through the feed-pipe that the bottom vibrates as it would of its own accord, then the amplitude of the vibration will be the largest, the pressure against the bottom the strongest and the greatest amount of fluid will be passed through the ports. All these considerations hold good for the electric circuit, and in experiments with high-frequency machines, in which these effects were purposely magnified with the view of rendering their observation more easy, I have found that that condition is fulfilled when the capacity, self-induction and frequency of vibration bear a certain relation, which observation I have since utilized in the adjustment of inductive circuits. You will note that this condition governing the rate of supply and discharge, most important in practice, especially when no positively acting mechanical means are employed for effecting the rupture of the dielectric, is a distinct one and should not be confounded with the condition de-

termining the oscillatory character of the discharge investigated long ago by Lord Kelvin.

The next step in the evolution of the principle and its adaptation to practical uses was to associate with the system illustrated in fig. 1 a self-induction coil L, as shown in diagram fig. 3, which modified the action in many now well-understood ways. In a simplified form of this arrangement the condenser, as a distinctive part of the system, was done away with, the necessary capacity being given to the coil itself, and for this purpose the latter turns of the wire were wound as illustrated in fig. 4, so as to allow the storage of the largest possible amount of energy. Then I associated a secondary coil S with the primary circuit P, as shown in fig. 5, this enabling the obtaining of any tension required. After this the arrangement in diagram fig. 6 was adopted as best suitable for the existing municipal circuits. Again the self-explanatory diagram fig. 7 typically illustrates a further improved disposition as used in some of these machines with two or more circuits. A modification of this plan with one continuous contact, common to the two circuits and independent interrupters for each of these allows easy adjustment of the phase of the currents through the primary, which is of practical advantage in some uses of the apparatus. Finally, in diagram fig. 8 is shown the exact arrangement of the parts and circuits of one of these small oscillators with a break similar to that usually employed in connection with induction

coils. Although the majority of the preceding arrangements have been described by me before I thought it necessary to dwell on them here in order to present clearly and comprehensively the subject.

A specific result of value in the operation of Roentgen bulbs is obtainable by the use of two circuits linked as shown in Fig. 7, or otherwise, or entirely independent with two separate primaries. Namely, in the usual commercial bulbs the vacuum gets higher when the current is passed through the primary in a certain direction and is lowered when the direction of the current is reversed. This is a direct consequence of some conditions which, as a rule, are present in the operation of the usual apparatus; that is, the assymetry of the opposite current impulses, the unequal size, configuration or temperature of the two electrodes, or like causes which tend to render unequal the dissipation of the energy from both the electrodes. It should be stated, though, that beyond a certain point, when the electrodes begin to act as entirely independent, the vacuum continues to increase, no matter which way the current is passed through the primary. In the scheme illustrated in fig. 7 or in its modifications referred to the trouble attendant upon the operation of ordinary apparatus is practically done away with, as the current through the primary is automatically reversed, and in this manner a tube which is first brought to the proper degree of exhaustion by means of one circuit can be worked for a long time without appreciable increase of vacuum or diminution of effectiveness.

A photograph of one of these finished instruments, (fig. 1) especially adapted to be used in the operation of Roentgen bulbs, or in general as a laboratory appliance in place of the ordinary induction coil gives an idea of the actual arrangement of the parts. The condenser (C fig. 8) is contained in a box B upon which is mounted in front the motor for controlling the circuits, in this instance simply a coil L actuating a spring (a), fixed on top of the same. This coil, designated as the charging coil, serves at the same time to raise the pressure of the source to any value desired for charging the condenser. This is an important practical advantage, as it enables to reduce the capacity of the latter, so that it need not be more than a few percent of that otherwise needed for an equivalent conversion of energy. Besides, the smaller the capacity, the quicker is the vibration and the shorter need be the high-tension secondary. The discharge circuit P surrounding the secondary coil S is formed of a few turns of copper ribbon and mounted on the top of the box behind the charging coil, all connections being as short as possible, so as to reduce as much as it is practicable both the self-induction and resistance of the discharge circuit. On the front side of the box (fig. 9) containing the condenser there are mounted the binding posts for connection with the line, two small fuses and a reversing switch. In addition two adjusting screws are provided for raising and lowering the iron core within the charging coil as a convenient means for varying within considerable limits the current of supply and regulating thereby the discharge of the secondary circuit.

rubber columns carrying
The instrument with the discharge rods, which are visible on the top, dismounted, can be inclosed in a box of 12x9x6 inches inside measure.

The mode of operation may be explained as follows. At (see fig. 8) the start, the spring contacts being closed and the condenser practically short-circuited, a strong current passes through the charging coil, attracting the armature fastened to the spring and separating the contacts. Upon this the energy stored in the coil, assuming the form of a high-tension discharge, rushes into the condenser, charging the same to a high potential. The current through the coil now subsiding, the attraction exerted upon the armature ceases, and the spring reasserts itself and closes again the contacts. With the closing of the latter the condenser is discharged through the primary or discharge circuit, the constants of which are so chosen that an extremely rapid vibration of the electro-magnetic system, including the condenser and primary coil, results. The currents of very high frequency thus obtained induce corresponding currents of high tension in the secondary. Simultaneously, however, with the discharging of the condenser the current from the source of supply again rushes through the charging coil and energy is stored for the next charge of the condenser, this process being repeated as often as the spring opens and closes the contacts.

Although the instrument contains all the essentials of an ordinary induction coil, it will be seen that its action is entirely different, and the advantages of this new principle over the old

are so great as to hardly require any lengthy comment. Merely to convey a true and more complete information I may mention a few of the most important ones. Take, for instance, the economy. The instrument referred to takes on a 110 volt direct current circuit, according to load and adjustment, from 5 to 30 watts. It gives a powerful stream of sparks 6 inches in length, but if it be desired this distance can be easily doubled without increasing the energy consumed; in fact, I have found it practicable to produce by the use of this principle sparks of one foot in length, involving no greater expenditure of energy than 10 watts. But in an instrument designed for a variety of uses a departure must be made from a design insuring the greatest spark-length. Of the total energy consumed by the apparatus fully 80 percent can be obtained in the secondary circuit. Owing to the small total energy consumed and the efficiency of conversion all parts of the instrument remain cool by long continued working, with the exception of the contacts which, of course, are slightly heated. The latter are subject to much less deterioration than is commonly the case, as the current from the condenser is small and moreover, does not, like in an ordinary coil, pass simply through the contacts and a few short connections, but has to traverse the primary coil, this reducing the current and diminishing very much the heating effects.

Consider next the advantages of the absence of fine wire in the secondary coil. Owing to the rapidity of vibration of the primary currents comparatively few turns of thick wire give the required pressure in the secondary circuit. To illustrate this fea-

ture by a practical experiment I take a simple paper cylinder, wound with only one layer of ordinary magnet wire, forming the secondary coil. In spite of there being only a few turns long sparks, several inches in length, are obtained, when the coil is inserted within or brought near to the discharge circuit of the instrument. A secondary of this form is simplest and best suitable for the production of long sparks, but it is somewhat inconvenient to handle.

The most advantageous features of these instruments lie, however, in the quality of the effects produced, which are the result of the rapidity or suddenness of the discharges obtained. To appreciate this feature we only need consider that a spark of, for instance, 6 inches in length, obtained with an instrument giving half a million vibrations a second, involves maximum pressures which, if produced with ordinary methods, would give sparks of many hundred feet, since the electrical force necessary to vibrate a certain quantity of electricity increases very rapidly, that is, with the square of the frequency of vibration. Therefore, pressures such as these here obtainable cannot be secured in any way by static machines or ordinary induction coils.

Still another feature of a more practical bearing I may illustrate by lighting a vacuum tube from an instrument furnishing currents of a frequency of much over half a million a second. Although the tube has a volume of only about two and a half inches it emits more light than a tube six or seven feet long and one and a half

inches in diameter, such as I have shown on other occasions, and that is a tube having sixty times the bulk and taking a proportionately larger amount of energy. So small a tube as this shown could not at all be brought to this luminosity by the use of the ordinary currents without getting soon overheated, and no better test of the increased efficiency of light production can be had than by producing a high luminosity in a small tube without undue heating.

Another convenient and advantageous feature of such an instrument will be found in its capability of being operated from alternating as well as from direct current municipal circuits. With the special object in view of enabling their being used to the best advantage on alternating circuits also I have determined the physical constants in a few types to suit circuits of the frequencies usually adopted here, that is 60 or 125 cycles persecond.

In the development and practical application of the principle underlying this kind of apparatus one of the greatest difficulties encountered was the insulation of the secondary coils and condensers, particularly of the latter. The stored energy of a condenser is of an explosive nature, and when released suddenly in a way as it is in these instruments it partakes much of the character of explosions of such a body as dynamite, and enormous maximum pressures result, which strain the dielectric layers in the condensers and coils to their utmost. No matter how good and thick an insulation is provided it cannot withstand such strains, if there be even a

slight absorption loss caused in any strained portion of the apparatus. An ordinary condenser, insulated as usual by thick layers of mica, which easily stands a few thousand volts of steady or slowly varying pressure, breaks down invariably; and no wonder it does; for, with vibrations of several hundred thousand a second, such a condenser with air-bubbles or cavities of any kind, unavoidable when the usual method of construction is followed, will convert into heat the larger portion of the energy supplied to it.

To investigate the flow of an alternating current through a coil with an iron core which is not laminated is hardly less crude than to carry on a research of rapid electrical vibrations with a condenser in which there are cavities or air-bubbles, or in which, in general, air has access to the highly charged conductors. No estimate of the vibration period of an electro-magnetic system can in such a case be made with any accuracy, whereas, when a proper plan of construction is followed and the dissipation of energy obviated, the experimental result closely agrees with the calculated period. By properly building up the condensers and coils I have produced electro-magnetic systems in which a slow vibration, once started, continues a minute or more, this indicating the absence of any serious friction loss. It is important to consider the preceding facts when dealing with standards and instruments of measure. A standard condenser prepared in the ordinary way of mica sheets and tinfoil, while indicating the correct value of capacity when used with a steady or slowly varying potential, will have its measured

capacity greatly increased when the variation of potential becomes extremely rapid. In like manner an electrostatic voltmeter with its vanes immersed in air, though a precious instrument with ordinary currents, is practically useless in the measurement of condenser discharges of frequencies of a few hundred thousand a second, its indication being far too low.

In view of the importance of the subject a few words on the process of insulating which has been adopted by me after several years of experimentation, may be of value. One form of apparatus as used by me is illustrated in diagram fig.10. A is a tank capable of withstanding great pressure, which is connected to a pump E and its reservoir H through a condensing reservoir F, kept cool by means of the coil pipe G. The tank A is likewise provided with a coiled pipe C, through which either steam or cold water may be passed at will. The condenser is built up of insulating and conducting sheets in any convenient way, several layers of very thin paper being put together, so as to avoid defects which may arise from small holes or punctures. For the same reason it is advisable to mix up the sheets when received from the factory, as a great number of them may be injured at the same place. The condenser c having been tested by the application of moderate electrical pressure as that of a supply circuit of 220 volts is placed in a tapering vessel B. A pipe D, reaching to the bottom of this vessel, may be provided, through which the insulation, when liquefied by the heat, may flow in, but this is of less importance. The vessel B containing the condenser being next placed in the tank

A and the top of the latter bolted down, steam is then passed through the coil pipe C and the insulating mass is kept at the right temperature (which is a little above the melting point of the compound) by regulating the steam supply. The pump is now connected with the tank by opening the proper valves and a vacuum of about 29 inches or slightly more is established. When the melted compound has thoroughly permeated the interstices of the condenser, steam is then shut off and cold water passed through the coil C. The process of slow cooling being pushed far enough the connections of the pump are reversed and air is forced into the tank A with the result of compressing strongly the fluid insulation and forcing it into all the interstices. The pressure is preferably maintained until the mass is solidified. The application of the pressure is not only of great advantage because the insulation is forced into the interstices and prevented from shrinking away when cooling, but, in addition, any small gas-bubble which might remain in the condenser and would otherwise at ordinary atmospheric or smaller pressure be fatal to the instrument, is strongly compressed and the danger considerably lessened. The mass in the tank A being solidified steam is again turned on the pipe C for a few minutes in order to soften the insulation on the periphery and allow the vessel B to be lifted out of the tank, whereupon the condenser is taken out of the vessel and the superfluous insulation cut off. In the same manner primary and secondary coils are treated. As insulating material I have found best to use a mixture of

beeswax and paraffine of low melting point, about half of each being taken. This gives a tough mass which does not shrink away much from the metal upon cooling. Condensers and coils manufactured in this manner will withstand incredible pressures. Very often in adjusting the primary discharge circuit it may happen that sparks of 3/8 or 1/2 inch dart across the condenser terminals, and yet it will not break down, although the dielectric is no more than a few thousandth of an inch in thickness. I have been unable to detect any increase of temperature whatever in the condenser after long working.

To enable the secondary coils to withstand the effect of the enormous pressures producible with these instruments I have recognized it as necessary to build them on the general plan illustrated in fig. 11. The diagram shows two flat spirally wound coils, S, S_2, which are connected with their outer ends to a contact plate p in the proper direction so as to form in reality one single secondary coil, the terminals of which are respectively at the centres of the two wooden spools upon which the two parts of the coil are wound. These spools are held together by a cylinder of thin fibre sheet ff, which is sufficiently strong to insure solidity and perforated in order to allow the melted wax to fill the hollow spaces when the coil is put through the insulating process before described. In the centres of the spools are fastened threaded brass bushings bb to which the free ends of the secondary coils S1 S2 are connected and into which can be screwed brass pie-

ces ss. The latter are fastened to the ends of the hollow plugs of hard rubber rr, through which pass flexible wires ww, very heavily insulated with gutta-percha which serve to connect the secondary high potential ends to the discharge rods supported on the top of the instrument (fig.9). It is advisable not to insulate the wires ww with soft rubber, for this kind of insulation is soon destroyed by the ozone generated at their surface in consequence of the streamers which will form even if the rubber be very thick. The thickness of the insulation between the superimposed layers of secondaries is practically determined from an approximate estimate of the difference of potential between adjacent layers. Originally I have used heavily insulated wires with from two to four braids, but presently I am using ordinary magnet wire which, in manufacturing the coil, is wound together with a string of a thickness equal to that of the wire. This is a convenient mode of insulating, not requiring specially prepared wire and secures excellent results. The middle of the secondary circuit or common joint of the two coils is connected to the ground, or to the mains, and this generally through the primary discharge circuit, the small contact plate or spring p serving to establish the connection, upon the secondary spools being inserted in the primary coil.

The length of each of the secondary coils is so determined that it is somewhat less or equal to a quarter of the wave length of the electro-magnetic disturbance produced in the secondary circuit based, of course, on the practical estimate of the

speed of propagation of the disturbance through this circuit. It is obviously understood that the length of the secondary circuit is made to approximate more or less a quarter of the wave length, according to how much allowance is made for the capacity of the circuit under normal working conditions. In the ordinary uses of the instrument as laboratory appliance chiefly for the production of qualitative effects of high tension discharges little allowance is generally made for the capacity of the terminals, but if the apparatus is designed, for instance, for generating a large quantity of streamers between plates of great surface, or for charging condansers from the secondary or for such uses, then the length of the secondary wire is made much smaller and advantageously an even fraction of a quarter of that wave length which is obtained without any allowance for capacity other than that possessed by the coil. Finally, if secondary currents of comparatively low tension are desired the coil is constructed preferably of one single spool and of only few layers all in close proximity to the primary, so as to increase the mutual induction co-efficient and reduce the resonant rise of potential as much as possible. The closure of the magnetic circuit by oxygen at ordinary or high pressure, while of little effect with low frequency currents, is of a remarkable influence with currents of these unusual frequencies, expecially when the conditions are favorable for the occurrence of resonant phenomena and I am anticipating practical uses of oxygen in this connection.

A secondary coil constructed in the manner illustrated

in fig. 11 has many important advantages, the chief ones being the safety in handling and the facility it affords for obtaining potentials far beyond those producible if the ordinary methods of construction are followed. In order to convey an idea of the pressures obtainable even with so small an instrument as the one described, a photograph of the same in action with two loops of cotton covered wire attached to the discharge rods, is added (fig.12). The outer wire loop was in the experiment only 22 inches in diameter to enable it being properly shown in the print, but could have been much larger, since two such parallel wires 15 feet long may be stretched from the secondary terminals of the instrument and practically the whole space between them, four inches wide, is seen in the dark covered with fine luminous streamers, that is, a surface of 5 square feet, and yet the energy taken from the supply circuit during the performance is less than 35 watts. To produce with an ordinary transformer such a quantity of these streamers, which may be needed for the manufacture of ozone or similar purposes, would require a considerably greater amount of energy and a more costly apparatus.

These extreme differences of potential obtainable by the use of the principle here involved are the result of the enormous suddenness or rate of change of the primary current impulses. In the ordinary method of varying the strength of the primary current either by alternating the same or breaking the conducting path we are limited to the comparatively insignificant rate of change pro-

ducible by means of a high frequency alternator or rapid break, but by the use of the condenser discharges there is practically no limit to the suddenness of the impulses, and any potentials and spark-lengths desired can be readily obtained. So, for instance, I have been able to produce, by applying the principle in a peculiar manner, immense electrical pressures, the theoretical maximum value of which can be measured only in many millions of volts, causing showers or continuous streams of thick, thundering sparks to dart out into space to a distance of eight or nine feet from an insulated wire, which behave sometimes like veritable lightening bolts and have afforded to the few who have witnessed them during the last two or three years in my laboratory a spectacle not easily forgotten. Nor is it at all difficult to increase, in a large hall or open space, many times the potential and sparking distance by the employment of such means and methods.

Although in these oscillators the great suddenness of change in the strength of the currents depends chiefly on the electrical constants of the circuits, some advantages of minor but practical importance may be secured by a proper construction of the devices, used as convenient, though not indispensable, accessories of the system for the purpose of arbitrarily making and breaking the circuits. Accordingly, I have devoted considerable time to their study and perfection, and in connection with the typical arrangements of the circuits illustrated in figures 1, 3, 4 and 5,

I have dwelt in my earlier writings on this subject on a variety of such circuit interrupters in vacuum, air and other fluids at low or great pressures.

It has been known long ago, since the investigations of Poggendorff, that, when the vibrator or break of an induction coil was inclosed in an exhausted vessel, the interruption of the currents was effected with greater suddenness, the vacuous space acting in a certain measure like a condenser, connected, as usual, around the break. My experiments with several kinds of such circuit breakers have led me to recognize that the vacuous space is not exactly the equivalent of a condenser, but rather of an absorbent, the increased suddenness being simply due to the rapid carrying away of the volatilized material forming the arc, and therefore being dependent on the velocity with which the disintegrated matter is carried away and also on the amount of the latter. Thus, with very hard platinum-iridium contacts and small currents there is little difference, but with soft platinum points and heavy currents the influence of the vacuum is well noticeable, while, with mercury or in general easily volatilizable conductors, the difference is very great. The size of the exhausted vessel is also of some consequence, the break gaining in suddenness when the vessel is larger. Looking at Poggendorff's observations in this light it appeared clear to me that only a small velocity of the particles composing the arc can be obtained, since the effective pressure, at

least with low frequency impulses depending on mechanical means and currents of limited strength which can be passed through the contacts without quickly destroying them, is necessarily only a minute fraction of the atmosphere, being, besides, very materially reduced by the oppositely acting attraction of the parallel current elements of the arc. Pursuing further this train of reasoning it seemed likewise evident that, if an insulating fluid be forced mechanically between the contact points with such velocity that the particles composing the arc were carried away quicker than it was possible with a small pressure producible in the gaseous matter in vacuum, the suddenness of disruption would be increased. This conclusion was borne out by my experiments in which I found that a fluid insulator, such as oil or alcohol, forced through the gap with even moderate velocity, increased very greatly the maximum rate of change of the primary current, and the length of secondary wire necessary for a certain spark length was in some instances reduced to 25 per cent of that usually required. The length of the secondary was still further reduced by the use of insulating fluids under great pressure. As regards the suddenness of the current impulse following the closing of the contacts, the introduction of an insulating space or film of greater dielectric strength than that of the air at ordinary pressure, though producing a distinct effect, is of small consequence when the interrupter in its operation actually breaks the arc, since the electro-motive force of a battery or municipal supply

circuit is generally insufficient to break down an insulating film of even so small a thickness as one thousandth of an inch.

The continued effort to perfect the various automatic contrivances for controlling the supply current has clearly brought out their mechanical limitations and the idea of utilizing the discharges of the condenser as a means for producing, independently of such mechanical devices, the sudden variations of the current, which are needed for many purposes in the arts, appears evermore a happy and timely solution. In this novel process a function of only minor importance is assigned to the mechanical means, namely, that of merely starting periodically the vibration of the electro-magnetic system, and they have no other requirements to fulfill beyond those of reliability in operation and durability, features which are left to the skill of the mechanic and which, in a fair measure, it was not difficult to attain in a number of types.

Considering, then, that the rate of change of the discharge or primary current in these instruments is made to depend chiefly on the physical constants of the circuit through which the condenser discharges, it is evidently of utmost importance to construct properly the latter circuit, and in the investigations which were carried on with this object in view, several noteworthy observations have been made.

First of all, one draws the obvious conclusion that, in as much as the primary coil in a transformer of this kind consists usually of very few turns of copper ribbon of inappreciable re-

sistance, the insulation between the turns should not require much care. But practical experience soon convinces him of his error, for, very often it happens that, owing to an exceptional resonant rise, the difference of potential between adjacent turns becomes so great as to rupture even a very good ordinary insulation. For this reason it was found necessary to treat the primary coils likewise in the manner described, thus securing the additional advantage of stiffness, which results from the expansion of the metal sheets and thickening of the insulating layers during the heating in vacuum and subsequent contraction of the metal in cooling to the normal temperature after the insulation has solidified.

Next the experimenter is surprised when realizing the importance of the proper adjustment of the length of the primary coil and its connections. He is naturally prepared to find that, since the discharge circuit is of small length, the introduction in this circuit of a very small inductance or frictional resistance would produce an appreciable difference in the result obtained as, for instance, in the spark length of the secondary coil. But he certainly does not expect to observe that sometimes as little as a quarter of an inch of conductor more or less would be of a telling effect. To illustrate: It is quite easy to produce with this kind of apparatus a spark of several feet in length, and by merely taking off or adding to the primary an inch of thick copper wire reduce the spark-length to one half. Observations of this kind impress the

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experimenter with the importance of close adjustment of the circuits and accurate determination of their constants. His attention is forcibly attracted to the advantages of reducing as much as it is practicable the self-induction and resistance of the discharge circuit, the former with the object of securing the quickest possible vibration, the latter chiefly for reasons of economy. He also recognizes the necessity of bringing down to the minimum the
and resistance
length of all connecting wires. A well constructed discharge circuit in a small instrument, such as the one described, should have no more than five percent of inactive conductor, its resistance should be negligible and the self-induction should be no more than a few hundred centimeters. I have found it almost imperative to use thin copper ribbon in the construction of the primary coils,
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and with these an observation, which is most curious of all, has been made. It occurs, namely, that, under certain conditions, the primary coil gets perceptibly cooler by continued working. For a long time this result appeared doubtful, but finally it was positively ascertained and ascribed to an exaggerated Thomson effect, owing to which heat is carried from the primary copper ribbon to the tin foil of the condenser.

It might not appear quite clear at first why the primary discharge circuit is so sensitive to variations of length, for a circuit of any length might be connected to the condenser and, pro-

vided that the relation between resistance, capacity and self-induction is such as to satisfy the condition laid down by Lord Kelvin, oscillatory discharge will take place. But it must be remembered that the velocity of propagation of the disturbance in the circuit depends on these quantities, and that the best result is attained when the velocity is such that a stationary wave is formed with a single node which is located generally, but not always, at a point of the discharge circuit or conductor equi-distant from the opposite condenser coatings. Under such conditions the maximum effective pressure at the terminals of the condenser is obtained. But this state of things is only possible when the speed of the propagation through the discharge circuit is such that this circuit is traversed by the disturbance exactly in the time interval needed to complete half of one vibration. Now, since the speed is extreme and the length of the circuit very small, entirely insignificant variations of the length may often produce astonishing changes in the performance of the apparatus. These statements, of course, should not be construed as generally applicable, for they refer only to such cases in which the vibration in the discharge circuit, started by one operation of the circuit controller, does not die out before the succeeding operation of the controller. This may be made clear by a mechanical analogue. Suppose a weighted spring is clamped in a vise and a sudden blow is struck which sets the spring vibrating.

Let the vibrations die out and let another blow be delivered. The spring will vibrate again as before, and it matters little what weight is attached to the spring, what the elasticity of the latter or, in general, what its period of vibration, and at what intervals the blows are delivered, the process of conversion of the energy of the blows into the energy of the vibrations will be effected with equal economy, except for secondary causes, immaterial for the present consideration. Exactly so is it with the electro-magnetic system, and in the early stages of development and practical adaptation of the prind ple underlying the instruments described, I have employed condensers, either ordinary or electrolytic, of very large capacity and have caused them to discharge at comparatively long intervals through a primary circuit of negligible self-induction and resistance, thus producing current impulses which would sometimes reach, at least theoretically, maximum values of as much as 100.000 amperes. A high maximum rate of change in the primary current was thus producible, but, nevertheless, the average rate of change was still small. Considering again the mechanical analogue before mentioned a valuable lesson is at once derived. Looking upon the weighted spring as an appliance for converting energy, both economy and output demand that the vibration of the spring should persist as long as possible and that the blows should be struck as often as it is practicable. To satisfy this twofold requirement the blows must of necessity be delivered while the

spring is still vibrating, and now it becomes most important to properly time the blows. Similarly again, in the electro-magnetic system the circuit controller must operate at definite intervals of time in order to secure the most vigorous vibration with the least supply of energy. In the construction of practical instruments the number of the fundamental current impulses is arbitrarily adopted, the condenser, being prepared by a special process, cannot be adjusted without great inconvenience, and the size and to a certain extent also the turns of the primary coil are likewise determined beforehand from practical considerations. Furthermore, it is desirable, for reasons of economy, not to resort to an otherwise convenient method of adjustment, which would be to insert a variable self-induction in series with the primary coil. These conditions render more difficult the exact adjustment of the various quantities, and I have sometimes found it of advantage to adopt one or other plan, such as will readily suggest themselves. For example, I have used an additional coil wound upon the primary and connected in parallel to the same, or I have completed the adjustments by determining properly the self-induction and capacity of the secondary coil.

In order to facilitate the observation and also to enable the exact determination of the oscillations of electro-magnetic systems as well as of the vibrations or revolutions of mechanical devices, such as the circuit controller used in connection, it was recognized as indispensable, in the course of these investigations

only during a short interval of time when the plunger was passing through the center of vibration, and the oscillations of the electro-magnetic system, composed of the condenser and generating coil, being properly determined so that fundamental resonance took place, it was found that, under such conditions, the electro-magnetic system entirely governed the vibrations of the plunger and that the variations of the applied fluid pressure, while capable of producing changes in the amplitude, were within very wide limits without any appreciable effect on the period of vibration of the mechanical system, the currents generated being therefore of rigorously constant period. The currents thus obtained were then utilized in a number of ways to produce uniform rotation.

Another way to reach the same result and in a more practical manner was to generate currents of differing phase by a steam engine of special design, in which the reciprocating motion of the work performing plungers and attached magnetic cores or coils was controlled by a freely oscillating slide valve, the period of which was maintained constant by mechanical means or by the use of an electro-magnetic system, similarly as before. A synchronous alternating motor operated by the two or three phase currents thus generated rotated with so uniform a velocity as to drive the wheel-work of a clock with fair accuracy.

Still other solutions of the problems referred to I may mention which, though less satisfactory, have proved sometimes con-

to construct a proper apparatus for such purposes. I determined from the outset to avail myself of what is known as visual synchronism. In this scheme usually a disk or cylinder with marks or divisions, which is rotated with uniform velocity, is illuminated by a periodically varying or intermittent source of light, the divisions appearing stationary in space when the revolutions of the disk are synchronous with the variations in intensity or intermittences of the light-giving source. The chief virtue of such a method evidently resides in the uniformity of the velocity of rotation or eventually in the constancy of the period of the vibration produced. Having been early confronted with the problem of rotating a body with rigorously uniform velocity, which is required in many instances, or with the similar problem of producing a vibration of constant period, I have devoted some energy to the study of this subject, and in the course of time several solutions, more or less practical and satisfactory, have presented themselves.

One of these, for instance, was to produce by means of compressed air or steam, the vibration of a freely movable plunger to which was rigidly connected a coil or core of an electric generator. By the reciprocating motion of the plunger alternating currents were generated which were passed through a condenser or else through the primary of a transformer, in which case the secondary coil of the latter was joined to the terminals of the condenser. Care being taken that the air or steam pressure was applied

venient and sufficient for many purposes. For example, a direct current motor with laminated fields or without any iron, was connected in series with a condenser through a commutator or interrupter fastened on the shaft of a light armature. This device was so constructed that it alternately closed and opened the terminals of the condenser, as usual in the instruments before described. The condenser terminals being closed, a strong current impulse passed through the motor, and upon the terminals being opened the discharge current of high tension rushed into the condenser. But the energy and duration of both of these succeeding current impulses, and consequently of all which passed through the motor, were made chiefly dependent on the self-induction of the motor coils and on the capacity of the condenser, and were therefore, with certain limits of variation of the applied electro-motive force, little dependent on the latter, and consequently a motor with a negligible friction loss, operated in this manner, turned with nearly uniform velocity. The latter was the more nearly constant the greater the controlling influence of the electro-magnetic system which, of course, was the most complete when the number of current impulses, the capacity and self-induction were so adjusted that fundamental resonance was maintained. As before stated, in most of these novel instruments described, such adjustments are observed and, whether provided with rotating interrupters or circuit controlling springs, they partake more or less of the virtue of the preceding principle.

For this reason the contact springs in these instruments do not fall into harmonics, as they often do in ordinary induction coils operated from supply circuits, where the physical constants are generally such that similar adjustments are impracticable.

It should be remarked that, since a long time, it was known that a direct current motor, driven with currents interrupted at regular intervals, shows a marked tendency to maintaining a constant speed, but by the introduction of a condenser in the circuit and the careful adjustment of the quantities this tendency is very much increased, and for many purposes a sufficiently uniform velocity may be obtained in this manner. Instead of using interrupted currents for operating the motor it is practicable to rotate a separate coil, wound either on the same or on a second armature, and to pass the alternating currents generated in this coil through the condenser. It is important for the attainment of a satisfactory result in such cases to determine the constants so that the amound of energy stored in the condenser should be as large as possible.

While a number of such arrangements were readily available, it was found, nevertheless, that they were inadequate to the many different requirements of the laboratory, and accordingly an instrument was devised which is illustrated in fig. 13 ab. It has proved itself to be so necessary and valuable an implement in experimental investigations, that its description here may afford

useful information. The cut is intended to show a substantial and carefully constructed clock-mechanism with the usual escapement e, gearwheels ggg, and a one second pendulum P. A small shaft s, carrying a disk D of large diameter, was geared to the clockwork through a pinion p of a proper number of teeth, such as to give to the shaft a velocity best suitable for observations. Now, in order to rotate the disk with a uniform velocity, some difficulties, well known to clockmakers, had to be overcome. The chief of these is due to the fact that the rotation of the shaft s, being controlled by the escapement e, which, at regular intervals, retards the the train of wheels ggg, is not effected with uniform, but periodically varying velocity, which may have all values from zero to a maximum, dependent on the driving weight W. Owing to this circumstance, when such a disk D of large diameter is rigidly geared to any kind of clockwork, it exerts, by reason of the great momentum which it necessarily acquires, a strong reaction upon the pendulum, altering the period of the same more or less, according to the momentum it possesses. This difficulty is known to exist, even in cases in which the step by step movement is practically done away with, as, for instance, in clockworks with centrifugal governors, or circular pendulums, in which slow oscillations are produced by the reaction of the moving mass upon the regulating mechanism. Some clockmakers have proposed an elastic connection between the

body driven and the escapement, but this does not away radically with the difficulty. On the other hand when, in an attempt to overcome this disadvantage of the step by step movement, a quick acting escapement is used, whereby the periods of rest are reduced, and consequently the influence of the momentum of the rotated body upon the period of the pendulum, the result aimed at is but imperfectly attained and, besides, such an apparatus is less suitable for observation. Namely, it will be recognized as desirable for a number of reasons, that the disk D should be rotated normally either once or twice a second, according to whether a one or one half second pendulum is used. This being the case the experimenter can render himself easily an account of the constancy of the speed by observing a mark m on the disk and noting that it occupies a fixed position in space, relatively to that of the pendulum, in a convenient phase of vibration. Furthermore, the computation of the vibrations is rendered simpler and more convenient under such conditions.

The problem clearly put was then, to rotate a body as the disk D, or other body, with any desired but uniform velocity in a way such, that the period of vibration of the pendulum was not much affected, even though the body rotated possessed considerable momentum. An entirely satisfactory solution of this problem was arrived at in the following manner. On the end of the shaft s, fig. 13 b, was fastened a light metal piece f in the shape of a cross,

carrying on two of its opposite sides pivoted pawls p, p_2, and on the other two light steel springs r, r_2, which pressed the pawls gently against the periphery of a washer w, which was provided with many very fine teeth or serrations cut sideways, similarly to those of escapement wheels. The washer w was arranged to turn very freely on the shaft s, and to it was fastened the disk D. The pawls p, p_2 were made with sharp edges to fit in the serrations of the washer w, and by these means the disk could rotate freely on the shaft s in the direction indicated by the arrows, but its rotation in the opposite direction was prevented by the pawls.

The operation of the apparatus will now be at once understood. On the start the escapement wheel e, was released by unscrewing the thumb screw t and shifting the sleeve S on its rocking support. The pendulum was next started and when the escapement wheel had attained the normal velocity, the sleeve S was slipped back quickly and fastened, control of the escapement wheel being thus given to the pendulum. The wheelwork and also the shaft s now moved with periodically varying velocity, but the disk D continued to move uniformly, the pawls p, p_2 slipping on the periphery of the washer w during the periods when the revolution of the shaft s was retarded by the pendulum. When, however, after some time, owing to the very small but unavoidable friction loss in the air and bearings the speed of the disk would slowly diminish and fall below the maximum velocity which the shaft s was capable of imparting

to it, then the pawls would give it a slight impulse, and in this manner the disk was kept constantly at the maximum velocity. By each swing of the pendulum the disk would thus receive one impulse, and its velocity depended on the amount of energy imparted to it by each of the succeeding impulses. This amount of energy depended, of course, on the velocity of the shaft s during the period when the escapement wheel was free, and since this velocity was determined by the driving weight, the speed of the rotation of the disk could be varied within certain limits by adjusting the weight. It will be observed that, generally, the disk would rotate considerably faster than the shaft s, but it was easy to adjust the driving weight so that the disk rotated just once by one swing of the pendulum. In producing the rotation by these means the influence of the momentum of the disk upon the period of the pendulum is found negligible. This result, of course, could not be attained by connecting the disk rigidly with the shaft s, even if a quick acting escapement would be used, as before suggested. The unifommity of rotation secured in this way leaves, for all practical purposes at least, nothing to be desired. The apparatus might have been improved by supporting the disk on an independent bearing and, perhaps, also by rotating it horizontally in a jewelled support. But the friction loss was very small, since, by arresting the shaft s suddenly, the disk would generally rotate something like one hundred times or more before stopping, and such improvements were thought

unnecessary. The vertical position was, however, chosen, because it was much more convenient for purposes of observation. In order to reduce the weight of the disk D as much as possible, a light frame, consisting of a circular rim with narrow spokes, was cut out of thin aluminum sheet, and black paper glued on the frame, all marks and divisions of the former being, of course, white. I found it convenient to draw concentric circles with a number of marks such that all vibrations within the range of the apparatus could be read off. In addition a segmental piece of hard rubber N, supported on a bar T and properly marked, was used to read fractions or, respectively, take corrections for any irregularity in the rotation during a prolonged period of time. Near the disk was placed a vacuum tube or, in its place, an adjustable spark gap l, which was connected to the secondary of a small transformer, the primary of which was positively controlled by the mechanical or electro-magnetic system the vibrations of which were to be determined. In preparing a spring of the desired period of vibration for one of the instruments described, for instance, the spring was provisorily mounted on the instrument and the latter put in operation. The disk, intermittently illuminated by the discharges of the secondary coil, was released from the pendulum and rotated until synchronism was attained, the revolutions being computed by observing the white mark m. The constants of the spring were then modified after a

simple calculation from the first result, and in the second trial, as a rule, the vibration was so close as to enable the use of the escapement, the adjustment then being completed, generally by altering the weight of the hammer on the spring until the marks on the disk, by the normal speed of rotation, appeared stationary in space.

The apparatus described in fig. 13 will be found very convenient and time-saving in a great many lines of experimentation. By means of the same it is practicable to rotate a body of considerable weight with uniform and adjustable velocity, and it lends itself to the operation of circuit controllers, curve-tracers and all kinds of such devices. It will be found most useful in tracing current or electro-motive force curves and a variety of diagrams, and will afford material help in determining a number of physical quantities. But its most valuable use in the investigation of electrical vibrations is, perhaps, for the purpose of determining exactly the angular velocities of dynamos, particularly of alternators. Among the various quantities which, in alternate current experimentation and practice, one has to determine very frequently, there are some which even in a laboratory or shop in the midst of the disturbances of a city or factory can be ascertained with sufficient precision, while there are others which can be only approximated, particularly if, as is very often the case, practical methods of measure must be resorted to. So, for example, the close measurement of resistances offers no difficulty, nor does that of

currents and electro-motive forces, although the degree of exactitude is necessarily smaller; but in determining capacities one is liable to make a considerable error, still a greater one in measuring inductances, and probably the greatest in estimating frequencies. In many places such crude devices as speed counters or tachymeters are still resorted to, and the experimenter is disappointed to realize that the accuracy of his long and painstaking tests is impaired because of his inability to determine exactly the frequency. To make matters worse, very often too, the latter is the largest and most important quantity. In view of these facts a description of the method adopted by me for the determination of angular velocities may be of some value.

The devices commonly used are illustrated diagramatically in fig. 14, a and b. On the shaft S (fig. 14 a) of the generator is fastened a commutator or circuit controller C, provided with any suitable number of segments, eight being shown in this instance. Four of these, 1, 3, 5 and 7 serve to establish the connections of the circuits, while the intermediate ones, 2, 4, 6 and 8 are entirely insulated idle segments. Assuming the generator to be an alternate current machine, the terminals t_1, t_2 of the armature winding, or of any desired coil or part of the same, are led through the hollow shaft, as may be the case, and connected to the diametrically opposite segments 3 and 7, while the segments situated at right angles, that is 1 and 5, are connected together

through a wire w of inappreciable resistance. Two brushes b, b_1, supported in an ordinary holder allowing their being shifted in any position, are arranged to bear upon the periphery of the controller C. These brushes are connected to a circuit comprising a condenser c of proper capacity and a primary coil p, which has but a few turns of very small self-induction and resistance and is joined in series with the condenser.

The operation of the devices is as in the instruments before referred to. When, with the rotation of the shaft S, the brushes b, b_1 are brought in contact with the segments 1 and 3, the condenser is charged to a potential which can be adjusted at will by shifting the brush holder. The condenser retains a certain charge until the brushes b, b_1 come to bear upon the connected segments 1 and 5, whereupon an oscillatory discharge through the primary p takes place with the result of inducing strong current impulses in the secondary s, which momentarily light up the vacuum tube or spark gap 1 placed in proximity of the disk D, which is rotated with uniform velocity, as before described. With the rotation of the circuit controller the brushes are again brought in contact with the segments 1 and 3, and the operations are repeated, at each complete revolution of the armature shaft a definite number of impulses being passed through the vacuum tube or spark gap. In the device illustrated there will be only two impulses for each revolution of the armature, but any greater number may be arranged for by

augmenting the number of the segments and connecting them in the same manner. It should be stated that the current impulses, which pass into the condenser whenever the brushes b, b_2 are on those segments which are connected to the armature coil, ordinarily produce no appreciable effect in the secondary s. This might be the case if the number of segments would be very large and would then be at once noted. The proper adjustment of the circuit through which the condenser discharges is, of course, preferable but not absolutely necessary.

When it is inconvenient to use the armature current, as illustrated in fig. 14 a, then the controller C is provided with two sliding rings r, r_2 (fig. 14 b), upon which are made to bear two additional brushes b_3 b_4. The latter are then connected to a direct current source, as the ordinary supply circuit, preferably through a self-induction coil, which serves to charge the condenser to a higher potential. The rings r, r_2 merely ~~xxxxxxx~~ convey to the segments 1 and 3 the current for charging the condenser, otherwise nothing need be changed on the devices.

The marks or divisions on the periphery of the disk D are suitably made so that by the normal speed of the generator they appear stationary in space. This being the case the speed may be at once and easily computed from the number of segments on the controller and that of divisions on the disk and from the speed of the latter. The frequency of the dynamo currents is then given by taking into consideration the number of poles.

In availing himself of this method the experimenter can

get the accurate value for the angular velocity, no matter how much the speed of the dynamo may vary, if he only takes the precaution to make his readings for electro-motive force, current, etc. at the instant the marks on the disk are stationary. Should the reading consume more time it is easy to take the correction for any variation by simply observing, with reference to a fixed line on the rubber piece N, the number of divisions which are to be added to, or deducted from, the speed of the disk.

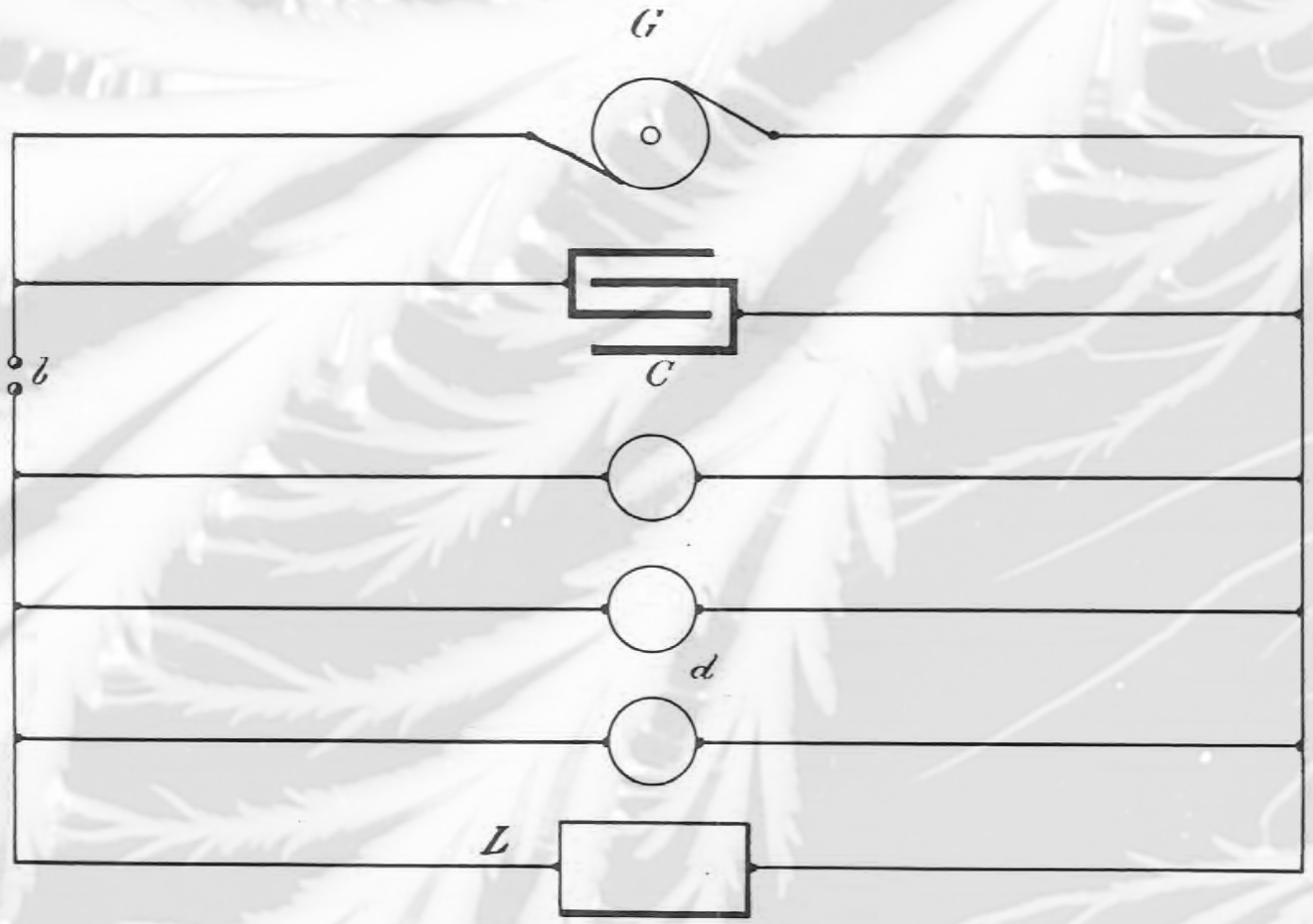


Fig. 1.

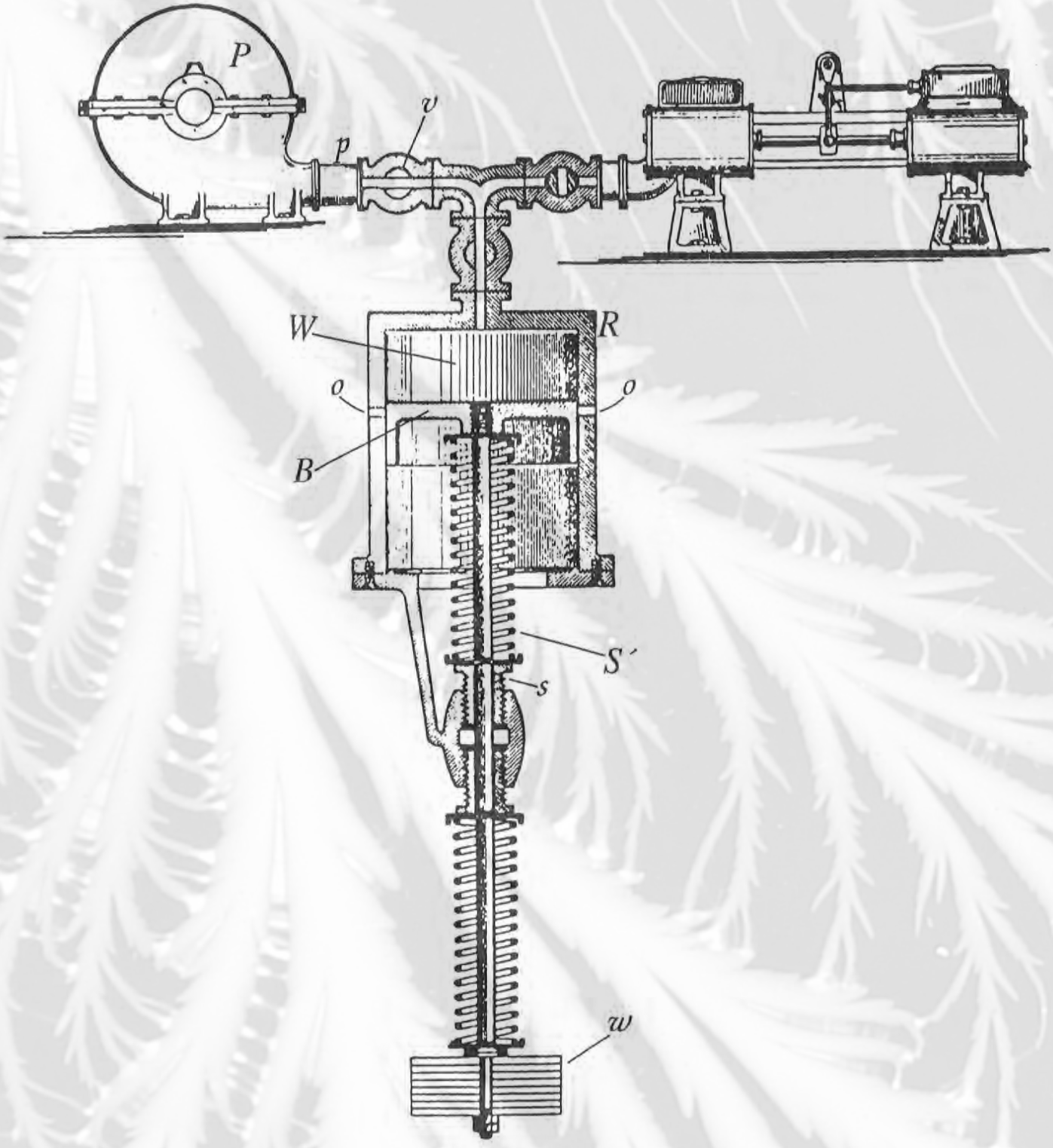


Fig. 2.

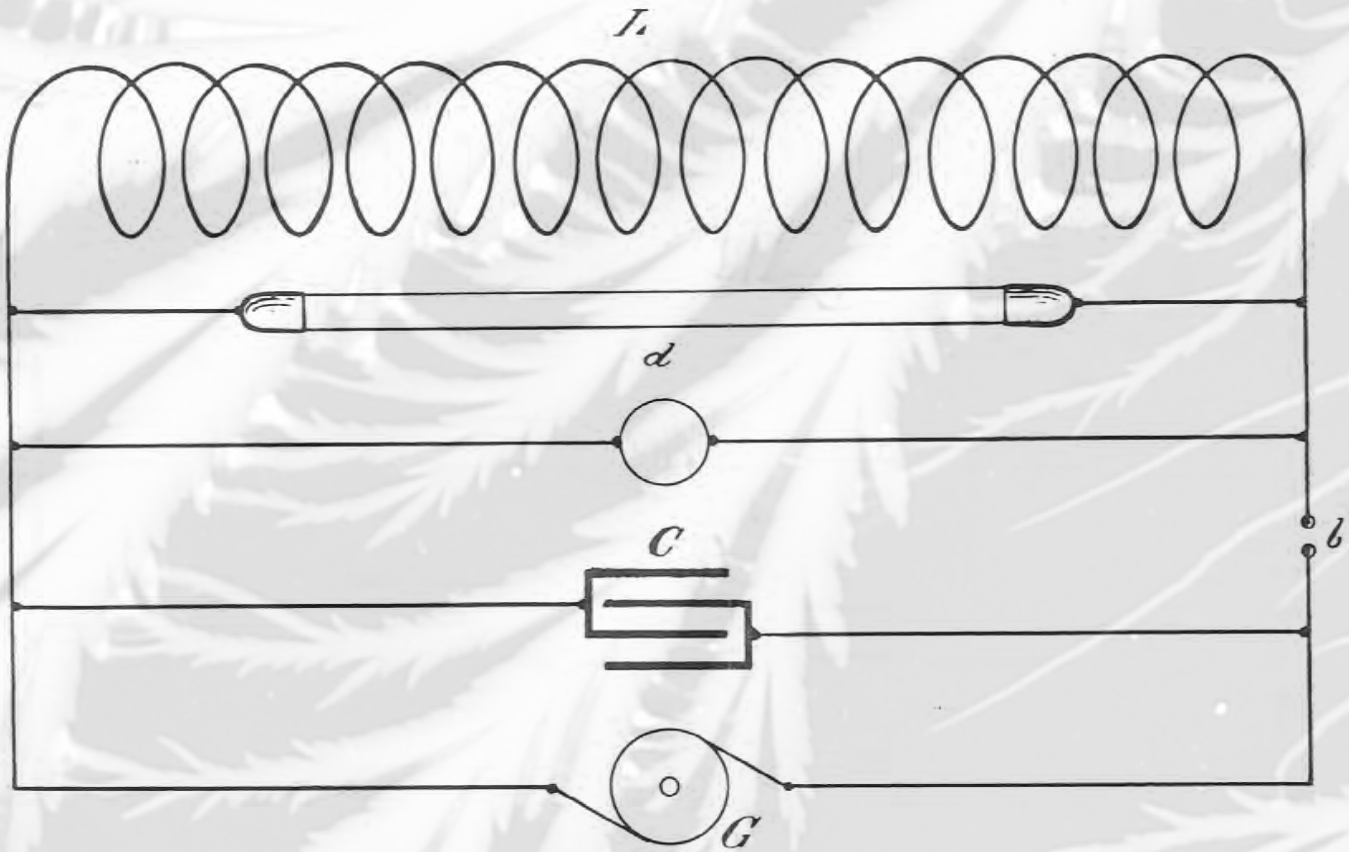


Fig 3.

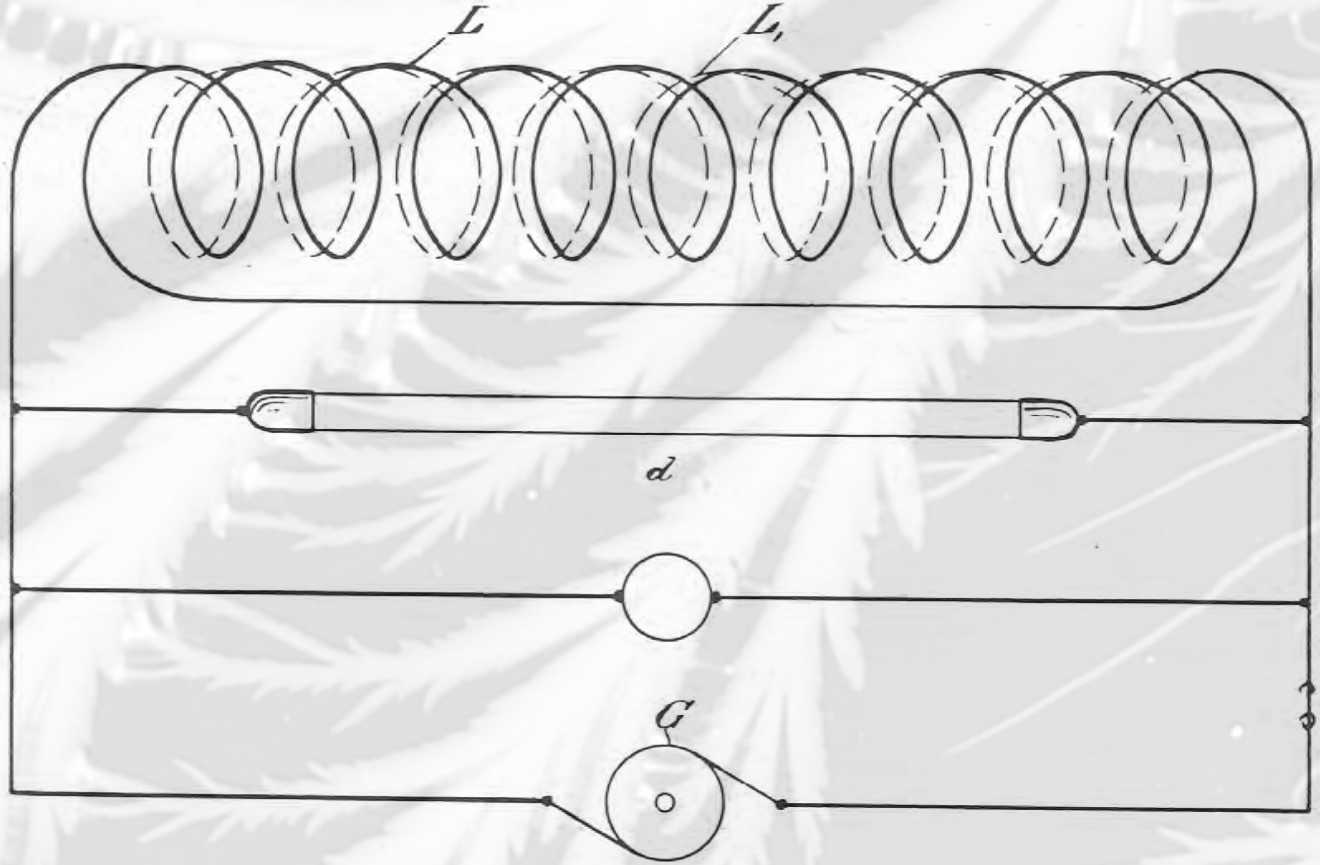


Fig 4.

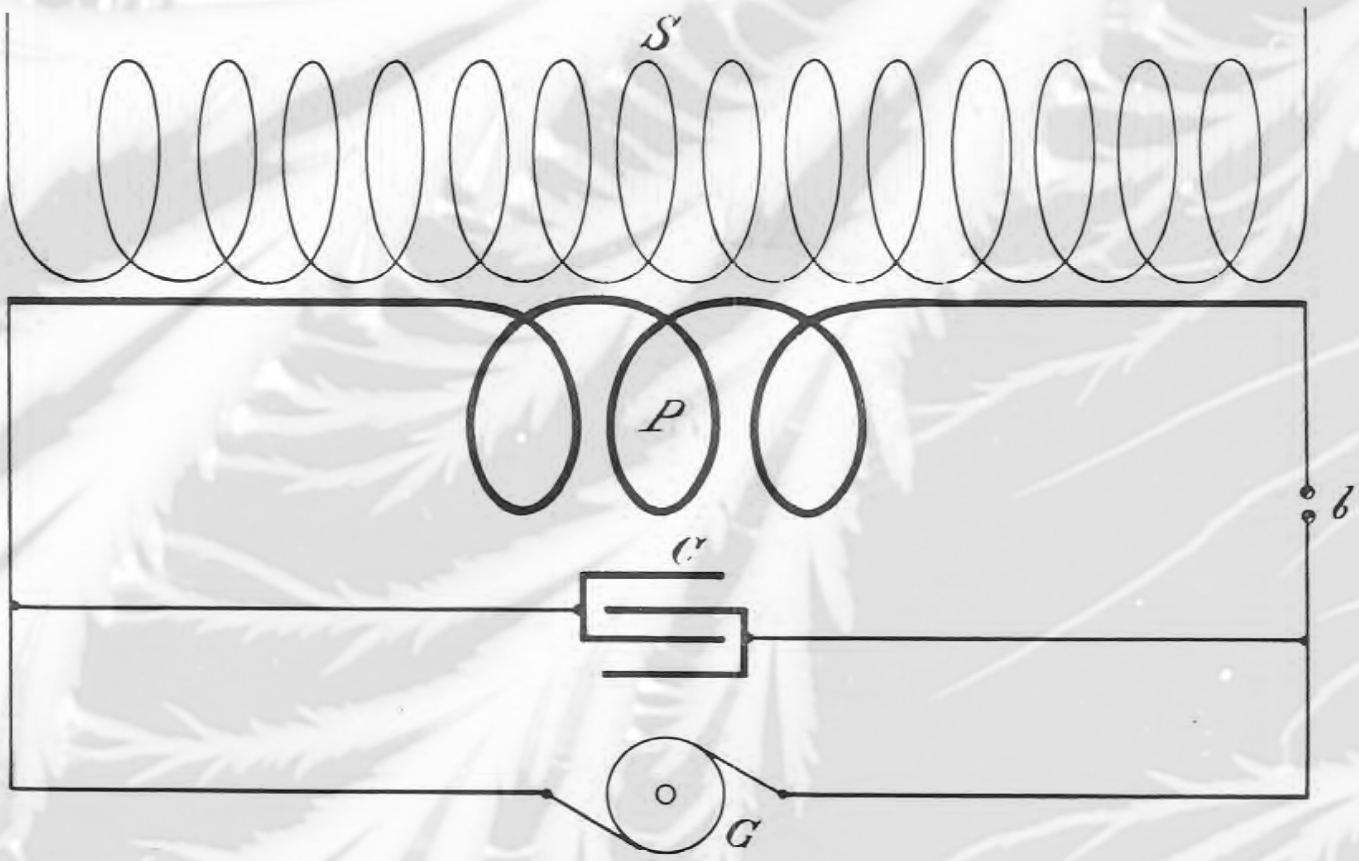


Fig 5.

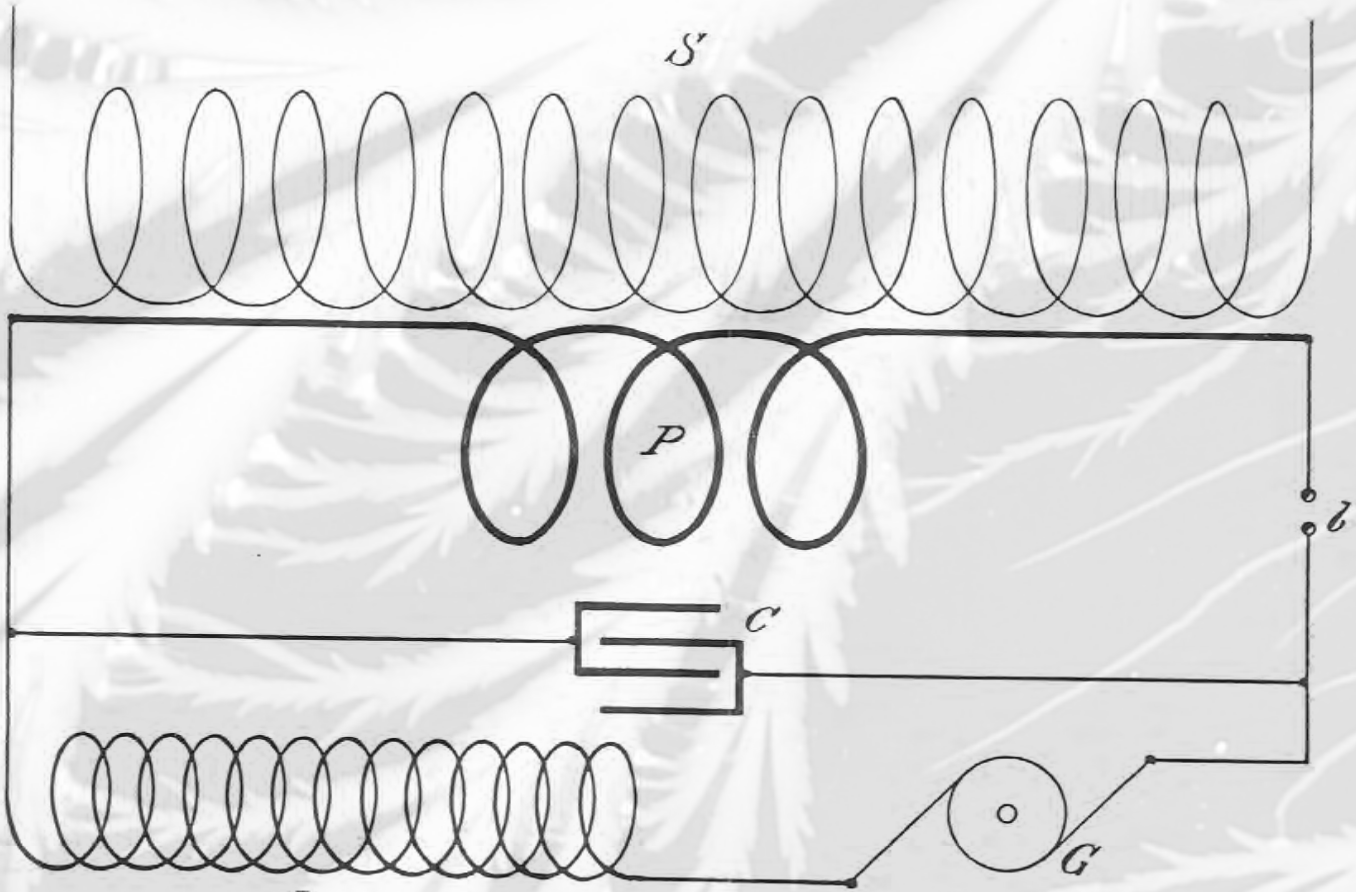


Fig 6.

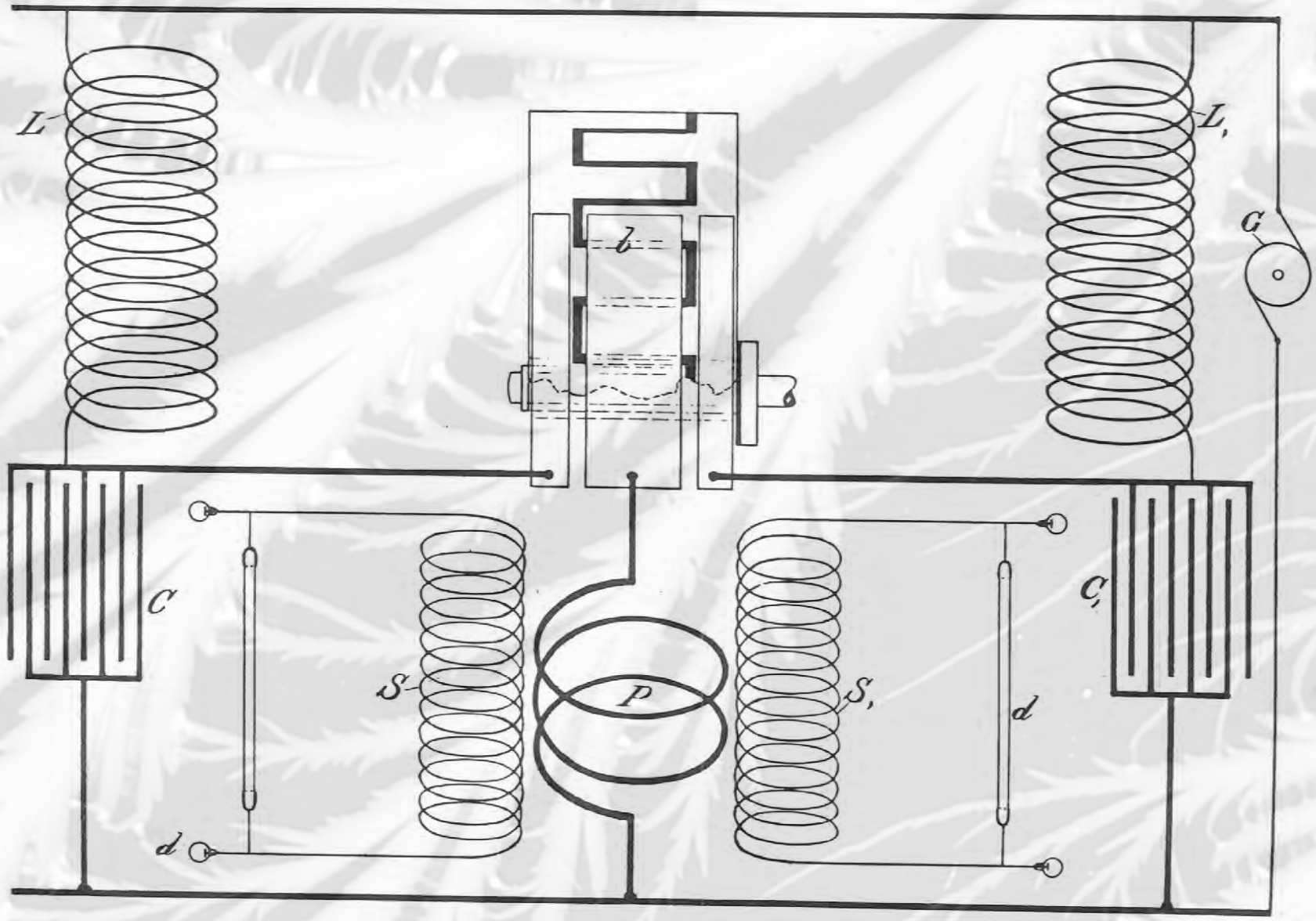


Fig 7.

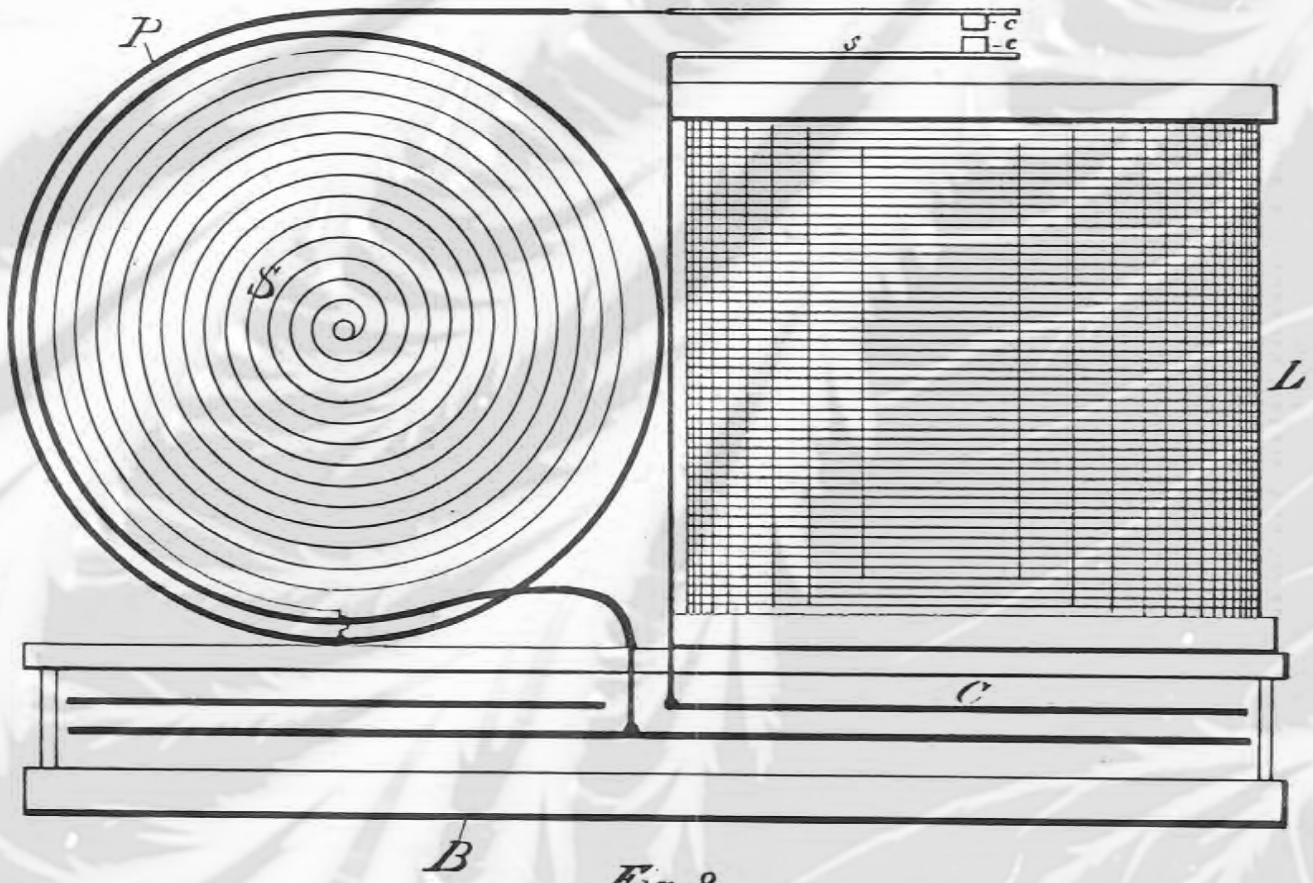


Fig 8.

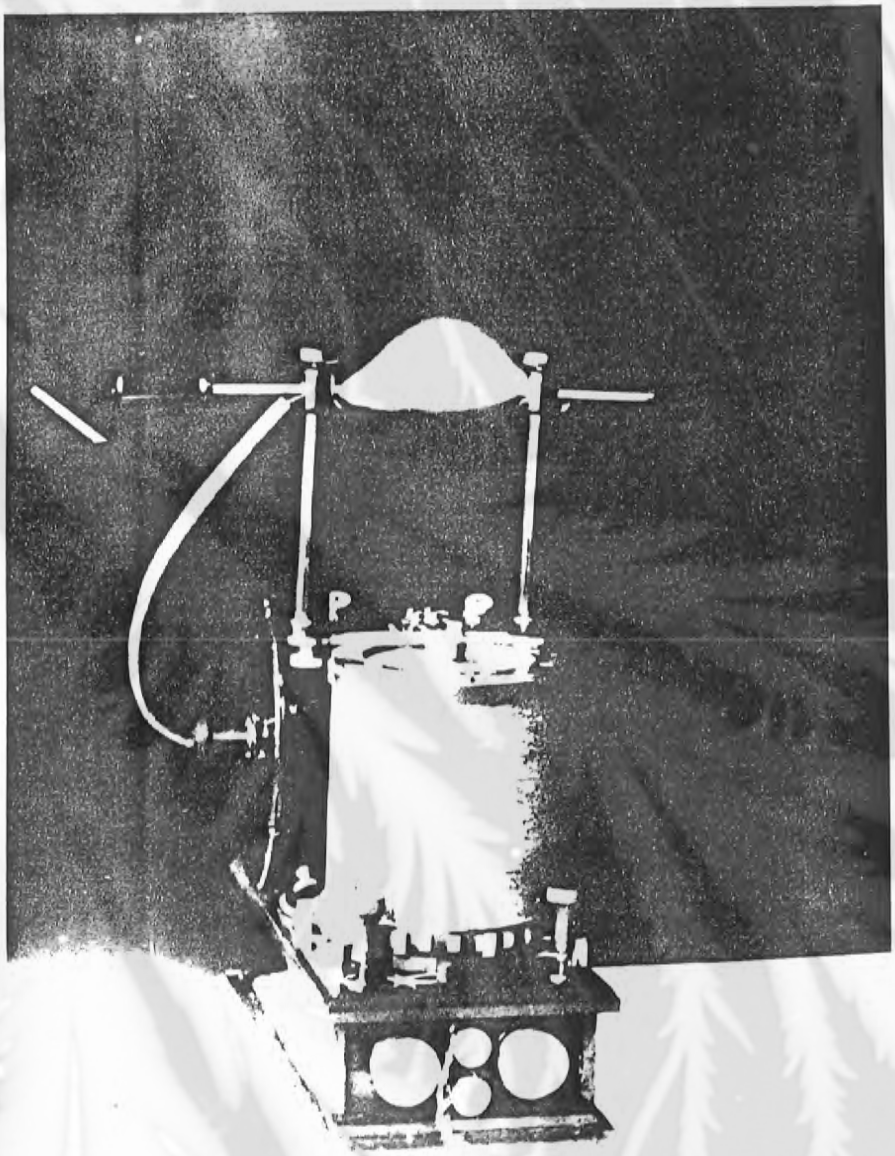


Fig. 9

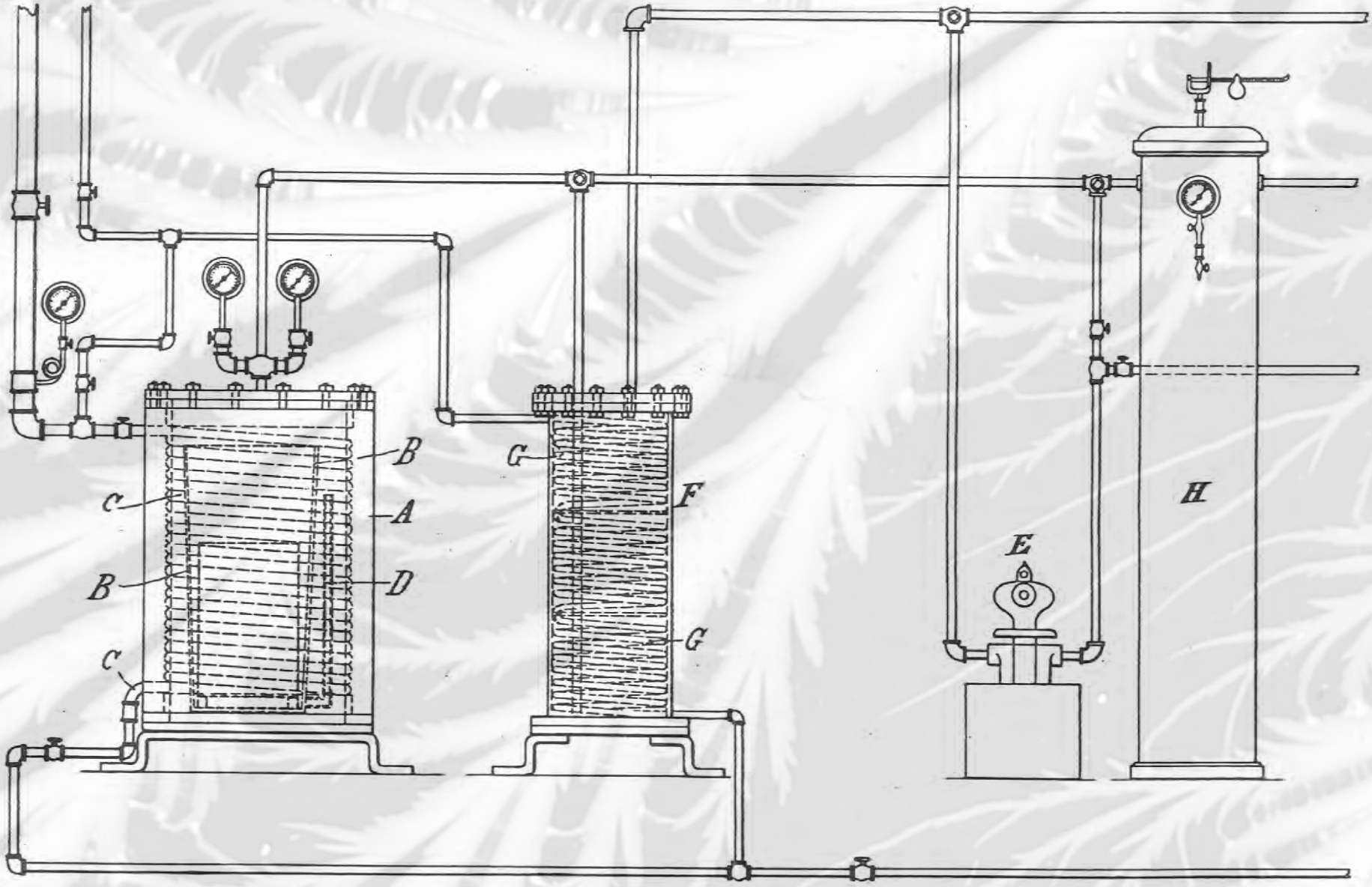


Fig. 10.

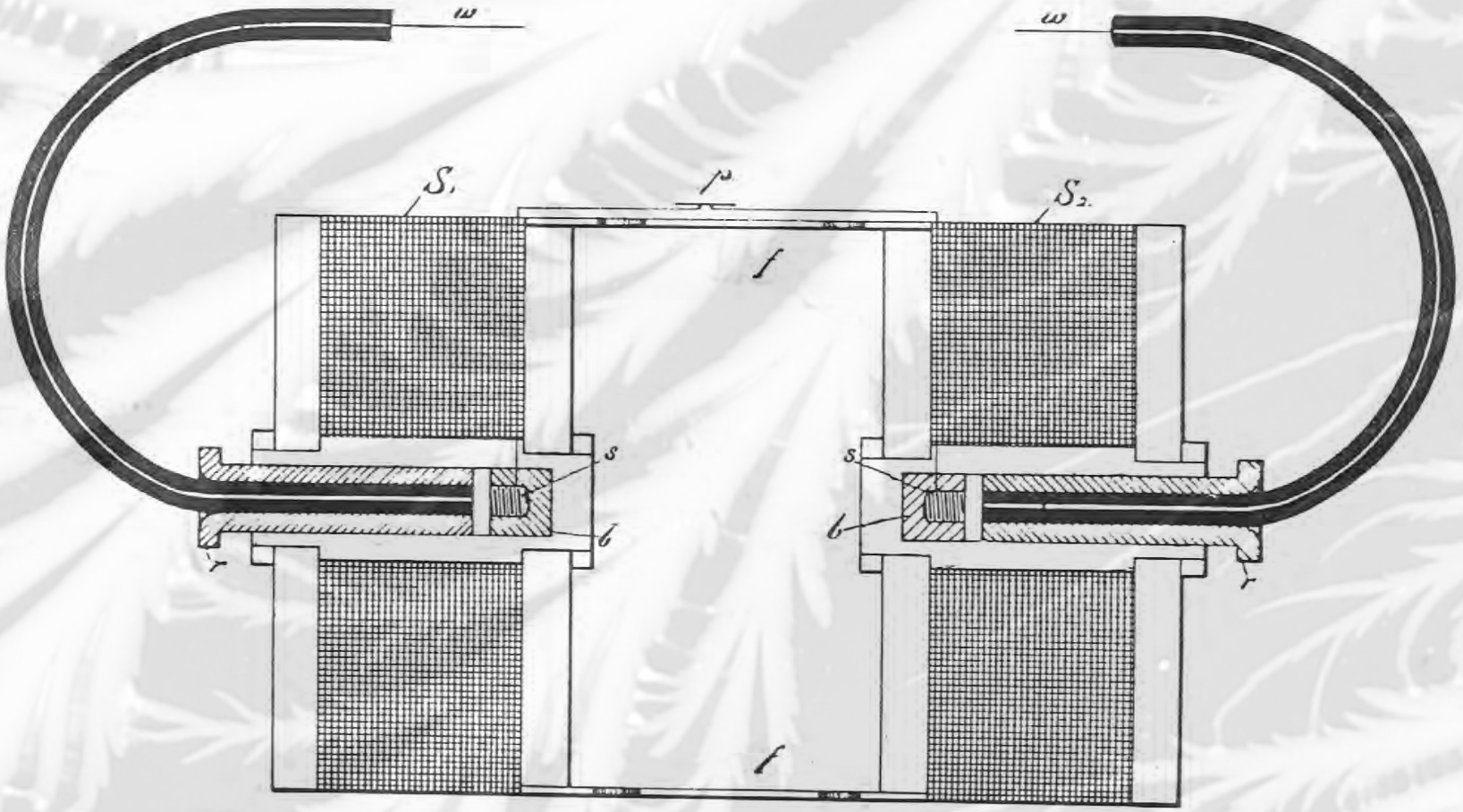


Fig. 11.

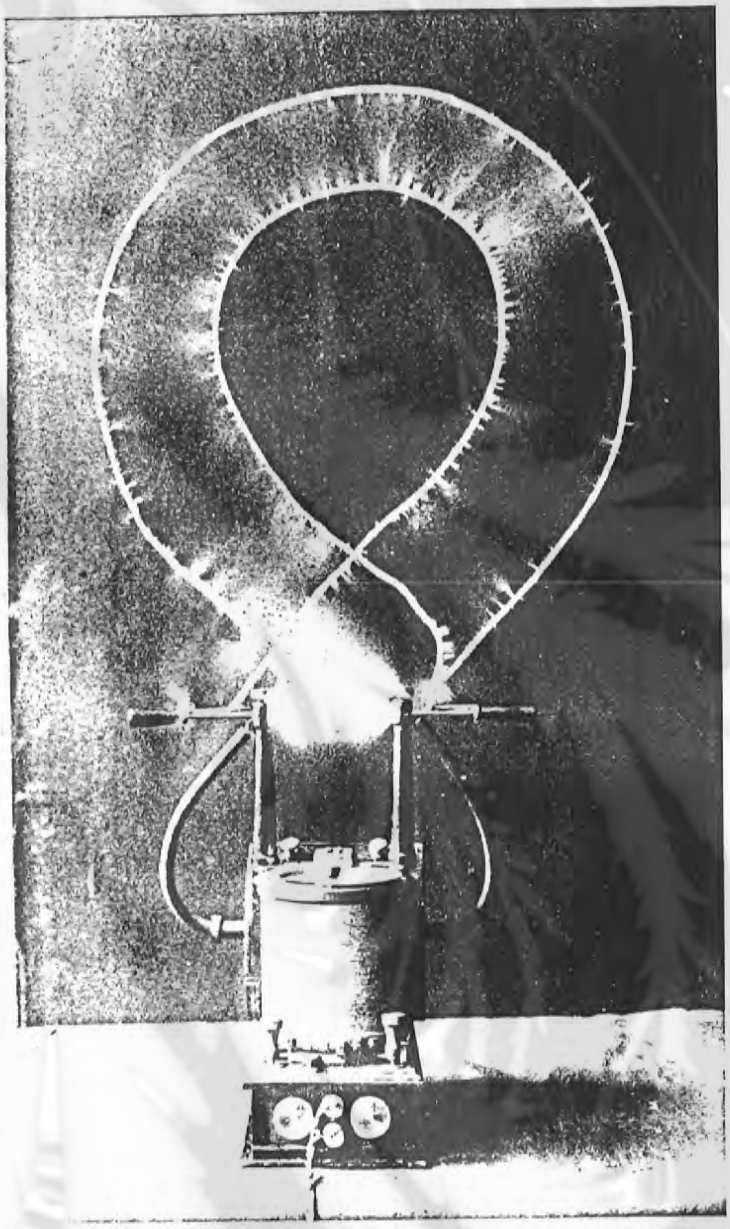


Fig. 12

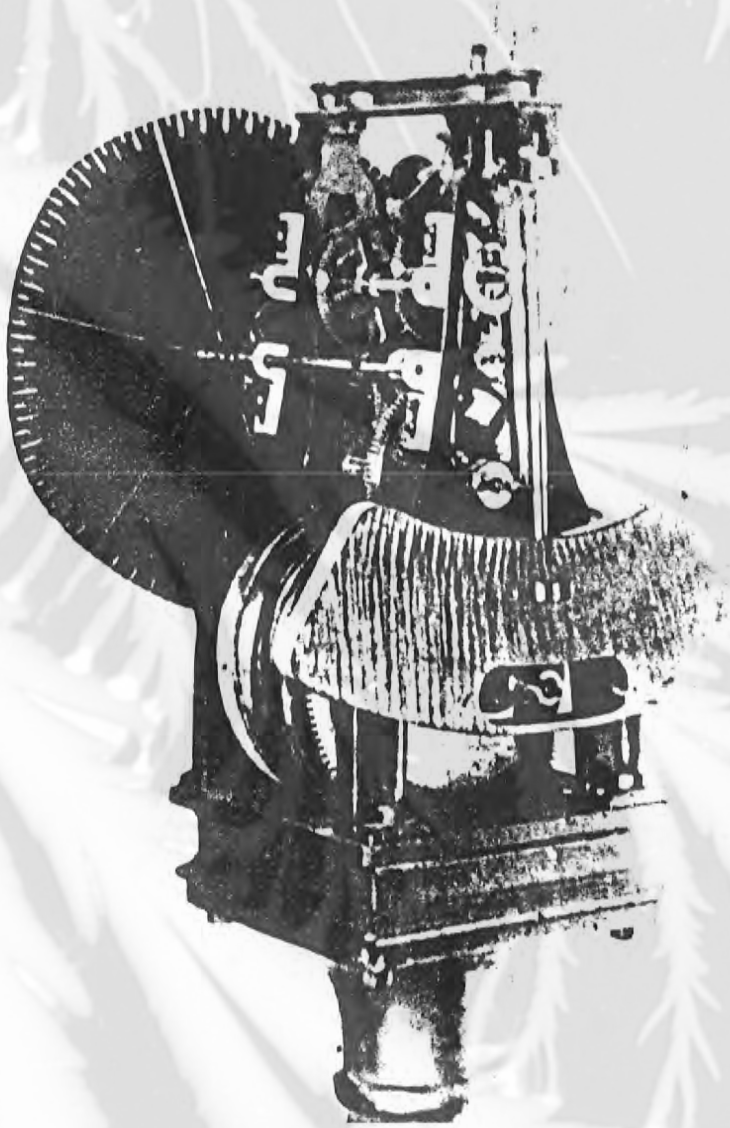
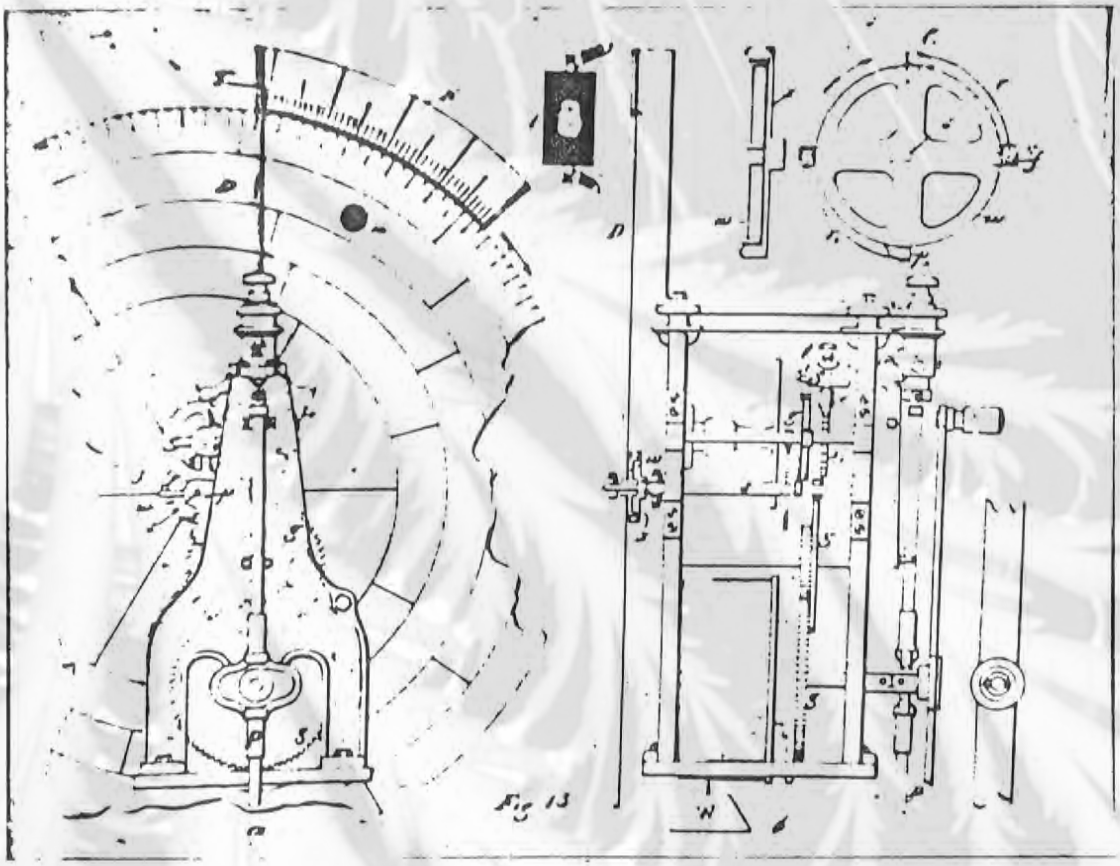
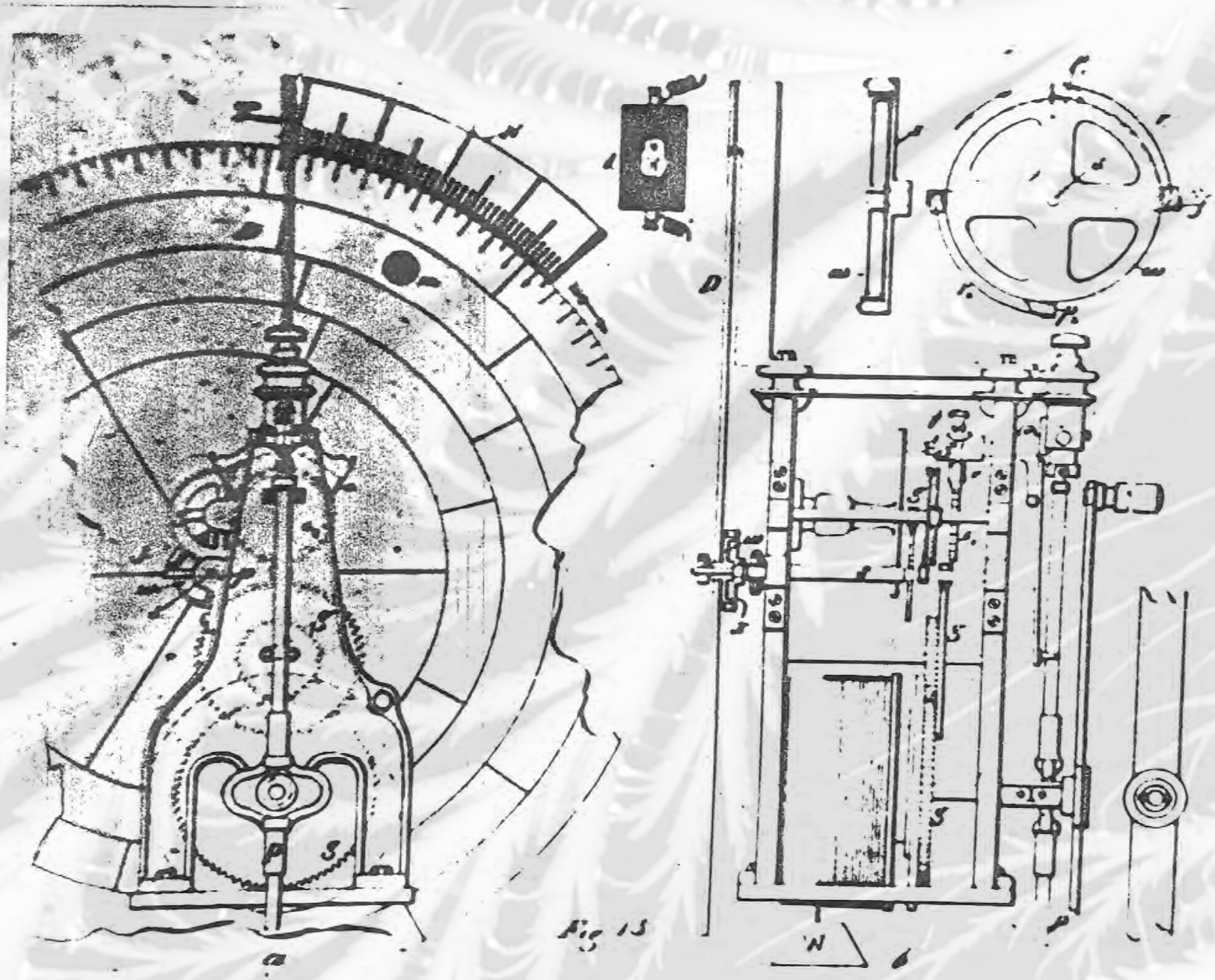
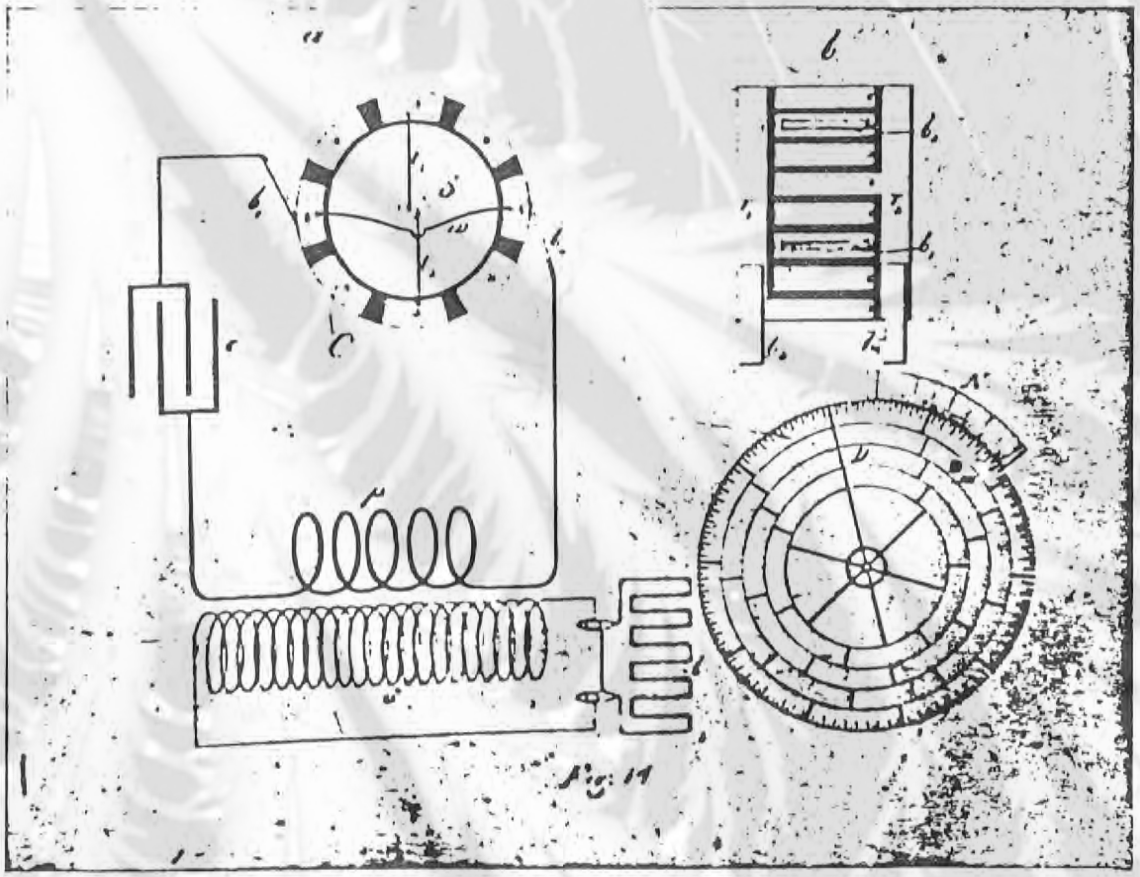


Fig. 13 cut







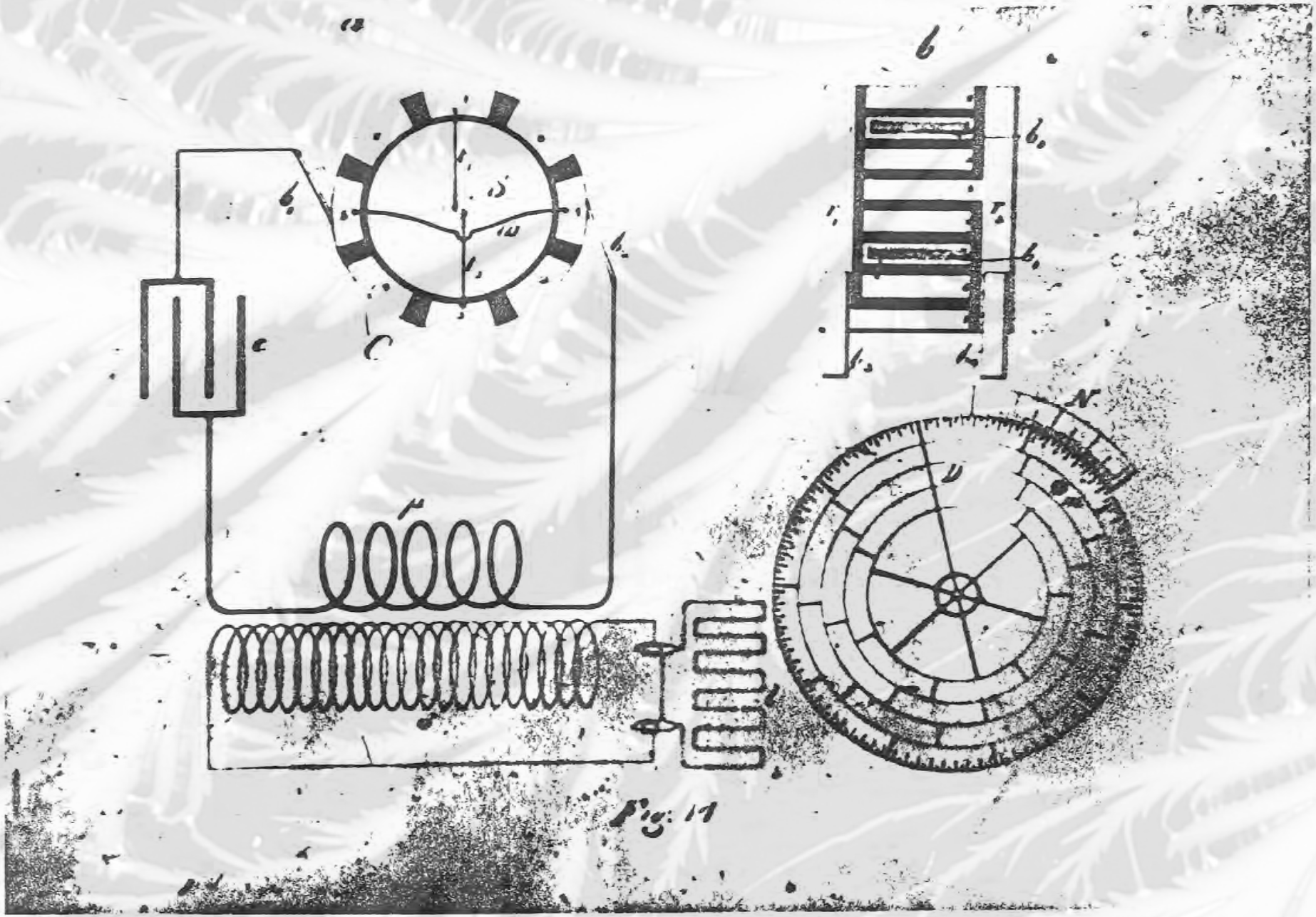


Fig: 11

CONFIDENTIAL

COLORADO SPRINGS
DIARY
OF
NIKOLA TESLA
1899 - 1900

TRANSLATED & TRANSCRIBED
INTO ENGLISH FROM
CROATIAN
TRANSLATION FROM ORIGINAL
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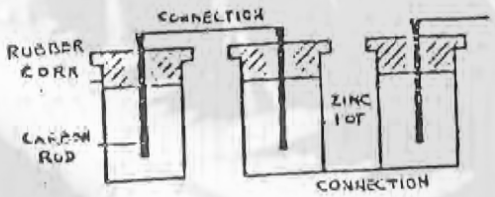
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Notes from Colorado Springs June 1 - 30, 1899

To these two applications have to be added, which I noted at Curtis, and some other material for patents, mainly foreign.

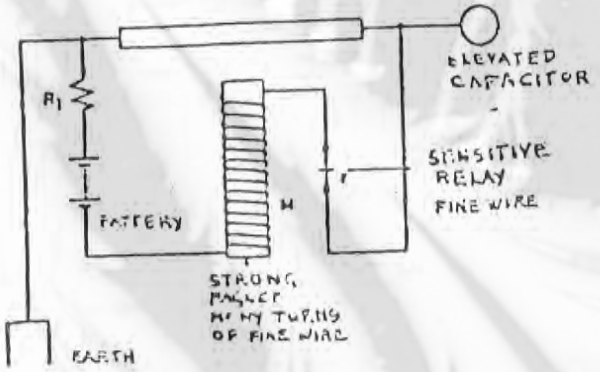
P. 25 June 1, 1899

It seems that the following plan is the best for the design of small batteries of very high emf, which are required to excite the vacuum tube of a telegraph receiver. For exciting the tube, a very small amount of current is necessary and that small amount of current could be produced by a battery.



From previous experiments it could be seen that a current of $1/20{,}000$ amp is quite sufficient. The approximate box dimensions--1/4 ft.^{3} The expenditures wouldn't be too high. Metzl containers, covers and carbon rods could be easily obtained.

Receiver connections are the same as at the New York experiment: if necessary, the resistor R_1 will be used to get the tube to the flashover state. It is very important, as with all the sensitive devices which have been used so far, that the dielectric is stressed exactly to the point of flashover.



The Magnet M has to have the resistance approx. equal to the internal battery resistance to get the highest efficiency. A 1,000 ohms relay will be suitable. The magnet has to be powerful to extinguish the tube when it is lit. This device will have to be sensitive to the point of providing the flashover with a very small current which is sent through the ground by means of an oscillator connected in a similar manner.

P. 26 June 2/1899

- Signal technique with useful capacitor methods
 - Telegraphy
 - Ships
 - Mainlands
 - Cables (this particular, but very powerful apparatus is required).
 - Protection
 - Against ship collisions
 - Against ship collisions with -bergs.
- Research
 - Originated from live beams from plants
 - Electricity
 - Disturbances which originate from ground
 - Magnetism
 - Static
 - Atmospheric
 - Ground Current
 - Sun influences, and so on

 Electricity
 - The location of layers
 - Magnetic
 - Non magnetic
 - In relationships to x-rays, other by repelling rays and dark sun rays.
 - Most important
- Measurements, etc.
 - Resistance, current, emf, and so on
 - Intensity, light, heat and so on
 - Measuring Instruments
 - Power
 - Current
 - Integrators of all types

P. 27 June 3, 1899

Various principle modifications which consist of energy accumulation of weak impulses received from a distance and the use of amplified action for the operation of a receiving device. Several methods for the achievement of this generally consist of the following:

- Resonance
 - Current commutation and charging
- Capacitor
 - Currents direction
 - with batteries
 - with gas tubes

 and charging
 - The use of dc high voltage currents
- Magnet
 - Current commutation for a relay
 - batteries
 - tubes
 - Current direction through a relay
- Dynamo Principle
 - Current Commutation
 - Directing
 - batteries
 - tubes

 > dc currents in an inductor
 - The use of dc currents

Low frequency currents in an Inductor

High frequency currents in an inductor

- thermal device
- electromagnet
- capacitor and so on

dc currents in an inductor

- relay, exciting m
- dynamo,
- capacitor and so

P. 28 June 4, 1899

Wireless telephone system

General remarks:

- Transmitters
 - with one impulse — For each telephone
 - with more than 1 impulse — impulse
- Receivers
 - with more than 1 impulse — For each telephone impulse
 - with one impulse
- The types of energy in transmitters
 - Electrostatic action
 - Current Action
 - rays (light, thermal, x-rays, and so on) — Types of energy that act on the receiver
 - Magnetic Action
 - Sound Action

 Types of energy that act on the receiver:
 - Electrostatic
 - Attraction & repulsion
 - Action of 2 circuits
 - Magnetic
 - Cathode rays
 - Thermal rays
 - Light rays
 - Mechanical
 - Cathode Action
 - Deflection by mechanical moving mechar
- The Instruments which will be used
 - Electrostatic machine
 - Induction coil
 - Oscillator
 - With one output terminal — Receivers instruments for various transmitters — which have to be made
 - with 2 output terminals
 - Batteries
 - Generators (high frequency)
 - AC excitation
 - DC excitation
 - Capacitor
 - Rheostat machine
 - Oscillator

To make up schematics of electrical circuits and so on.

P. 29 June 5, 1899

Induction method, the results for the device which will be used are calculated based on the equation:

$M = p^2 s^4 W_p V_t^2 / 32^2 D^6 S^2$ (this equation is very doubtful)

M = power in secondary or primary circuit

$p = 2\pi n$ estimated at $40,000 = 4 \times 10^4$

s = length of one side of the square circuit = 1,200

W_p = power spent in the primary = 4×10^{10} ergs (assumed)

V_t = total wire volume in both circuits = 25×10^3 cm^3

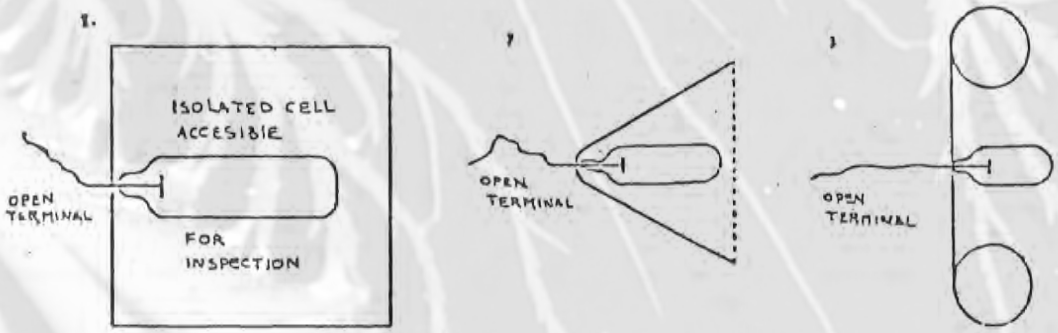
D = Distance of circuit center to center (horizontally)

S = Specific wire resistance 1.7×10^3

If we take into account that that must be at least 0.3 erg because of the relay action, we will find that with the above electrical circuits under such conditions, it is possible to achieve simple transmission of approximately one mile. With circuits of 1,000 m^2 in the area the same achievement could be successful at the distance of 30 miles. From here on the inferiority of the induction methods seems to be large in comparison to the load disturbance of ground and air methods.

June 6, 1899

Device with mono-anode tube for the purpose of producing intensive rays. Because there are practically no limits in oscillator power, there is now a problem of how to make a tube which would withstand every desirable voltage. The tubes made in New York were made with aluminum covers, or without them, but in both cases there was a voltage limit and therefore only a small portion of the obtained emf could have been used. The glass bottom would be broken by the electrical discharge, and when an aluminum cover was used arcing occurred in the cover direction. Submersion in oil or any other liquids is unsuitable. The best result will probably be achieved with electrostatic protection of the sensitive portions of the tube. This idea was followed on numerous experiments. Now testing is proposed of the devices shown below:



P. 30

Certainly it is necessary that the insulation body has the distributed capacitance in such a manner as to prevent the current streamers occurrence. The capacitance has to be such as to create the maximum emf at the open termina!

June 7, 1899

The approximate estimate of the number of primary turns which has to be used in the experimental station:

$$Ls = \pi \left[4A \left(\log_e \frac{8A}{a} - 2 \right) + 2a \left(\log_e \frac{8A}{a} - \frac{5}{4} \right) - \frac{a^2}{16A} \left(2 \log_e \frac{8A}{a} + 19 \right) \right]$$

Here A designates the radius of the circle = 25 ft. = 300 in. = 762 cm

a designates the radius of the conductor of 13/32 in. = 1.03 cm.

$8A/a = 5919$; $\log_e \frac{8A}{a} = 3.772248 \times 2.3 = 8.6762$

$4A = 3048 \qquad 2a = 2.06 \qquad a^2 = 1,061 \qquad 16A = 12,192$

$$Ls = \pi \left[3048 \times (8.6762 - 2) + 2.06 \times (8.6762 - 1.25) - \frac{1.061}{12,192} \times (17.3524 + 19) \right]$$

Since the last sum is negligable we will have

$Ls = 3.1416 \times (3048 \times 6.6762 + 2.06 \times 7.4262)$

$= 63,976.67$ cm or approx. 63,900 cm.

Two windings in series will have approx. 255,600 cm.

June 7,1899.

The approx. estimate of primary turn inductance used in the New York experimental oscillator on a vertical frame.

Turn diameter = 8 ft. = 240 cm. This gives A = 122 cm.

Conductor diameter = 13/16'

a = 13/32 x 2.54 = 1 cm. approx.

$\frac{8A}{a} = 976 \qquad \log_e \frac{8A}{a} = 2.98945 \times 2.3 = 6.875735$

$a^2 = 1 \qquad 4A = 488 \quad 16A = 1952$

$$L = \pi \left[4A \left(\log_e \frac{8A}{a} - 2 \right) + 2a \left(\log_e \frac{8A}{a} - \frac{5}{4} \right) - \frac{a^2}{16A} \left(2 \log_e \frac{8A}{a} + 19 \right) \right]$$

$$= \pi (488 \times 4.875735 + 11.2515 - \text{small portion})$$

$L = 3.1416 \times 2390.6115 = 7210.345$ cm.

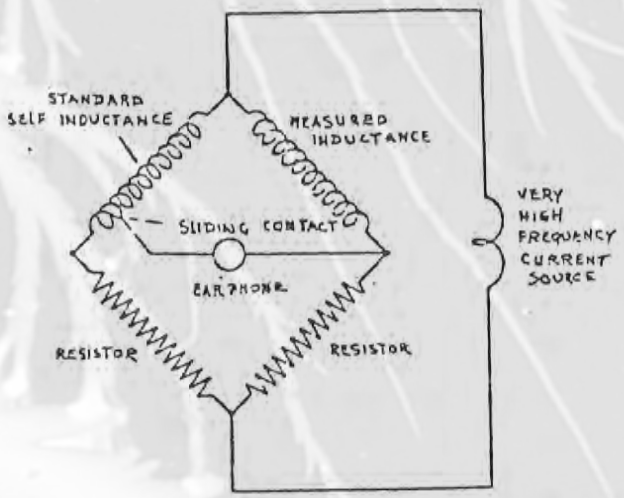
This will be a little higher if the terminals are sufficiently close, approx. 8,000 cm.

June 8, 1899

The method and device for the purpose of determining self-inductance and capacitance, particularly suitable for determining small inductances,

Because the resistance could not be neglected when the frequency of the current is high, the inductances could be compared as follows:

The self-inductance standard is equipped with a sliding contact to make the number of turns variable as desired.



Two resistors are connected in a bridge arrangement and they are adjusted according to the high frequency current source and the inductive coil which is measured. Two opposite points, of which one is movable, are connected with the telephone ear phone. When no sound could be heard, the two indictances--the one we measure and the corresponding portion of the standard, are balanced or when the ear phone is silent, they are practically equal, if their values are suitably chosen.

With the inductances so determined, the capacitance could be easily measured on this basis. It is possible to omit high the frequency source and use a very fast capacitor discharge instead. Auxiliary resistors have to be determined so that the resistances in two branches through which current is divided are equal or at least approximately equal.

P. 32 - June 9, 1899

The purpose of the next experiment is to check whether it is practical to use an air cylinder or a cylinder filled with some other gas, as a detector of electrical disturbances at a distance. That would be based on the principle of the RIS thermometer as it was experimented with in New York. The schematic of the device is shown in the figure below. There is a reservoir V, preferably with a smooth and shiny mirror like surface to reflect the rays into the center. There is a resistor R of small mass in this reservoir. That resistor could be conveniently achieved by connecting pencil tracks mm by means of two terminals T & T_1 which are supported by glass plate P. The mass has to be small in order to achieve a temperature rise of the pencil track by means of a very small current, or conductors and that way the air in the reservoir is heated,

Let's assume that the tube is 1/10 mm in diameter and 10 meters long.

P. 33

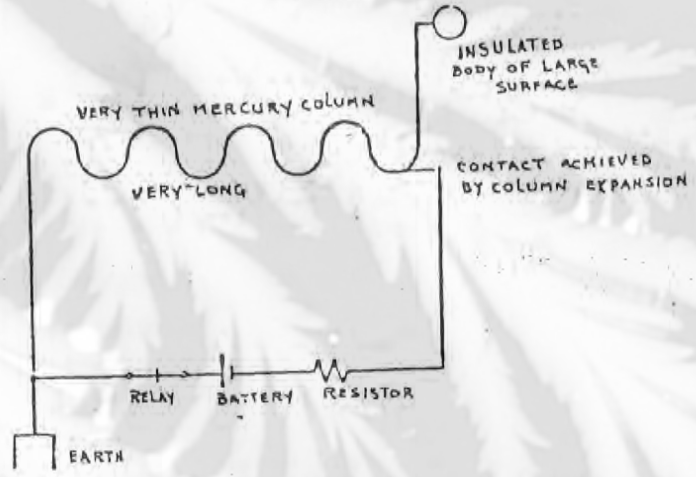
Each resistance will approximately 1000 ohms.

Then $RI^2 = 1000\ I^2 = 1/10$, if we accept that the supplied energy is 1 erg, this gives $I^2 = 1/10^{10}$ or $I = 1/10^5$ amp. The column in the tube will expand for 1 degree: 0.00018 x 10 = 0.0018 meters or 0.18 cm. or 1.8 mm.

The cylinder volume will be 0.01 x 10.000 = 100 mm^3 or 0.1 cm^3.

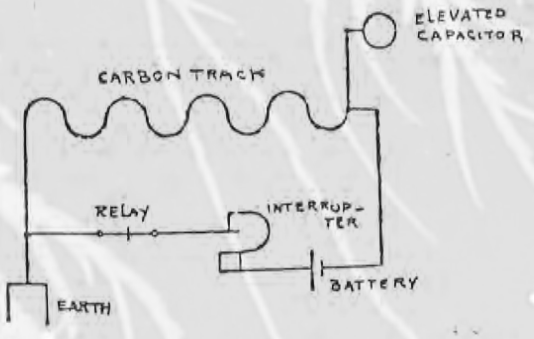
That will weigh 0.1 x 13.6 = 1.36 grams. The mass will amount to 0.00136/9.81 Now, if the temperature would be increased by 1°C, we would need 41,600,000 erg per gram. As the specific heat of mercury is 0.0319 there will be 41,600,000 + 320/10,000 = 41,600 x 32 = approx. 1,330,000 ergs necessary.

This indicates that for the above assumptions, the indications of electrical disturbances by means of a mercury column would not be efficient, unless the c could be made much thinner.



P. 33 June 11, 1899

The following method and device, for detecting weak signals transmitted through a media, seem particularly suitable for telegraphy. This idea was tested in New York, but the results were not satisfactory. Now the experiments will be performed with the device that is shown below:



The basic idea is to establish a current circuit, the resistance of which will be reduced when the current flows through it and its mass will be as small as possible. The specific heat of the material from which the circuit is made has to be as small as possible as well. The best way I discovered so far is to make a track with a pencil which is of the necessary thickness and connect that track to terminals. The measured track is of high resistance. This conductor I connected with one end to the ground and the other to the elevated body with a large surface. The conductor is then connected within a circuit which consists of relays and batteries, which are suitably chosen and connected, for example, as on the above diagram.

P. 34

When a weak impulse gets through, it will reduce the carbon resistance so that more current will flow from the battery and activate the relay. Then the relay, by any suitable method will interrupt the battery current, and the normal mode of operation is re-established. Only the relay could be used for current interruption or the auxiliary magnet if used as shown. This carbon track could be connected as a bridge in order to increase the sensitivity.

(This has to be continued)

June 12, 1899

A suitable method for achieving a conductor (that is desired to be poor) of small mass which is instantly evaporated or destroyed by the influence of the current from the battery, but which could be recovered very simply and automatically, consists of the following:

Two terminals are attached to an insulating plate, preferably made from glass, and then the plate is coated by a thin layer of poor conductive material so the terminals are bridged and form a path for the current flow. The best method to materialize this idea is as follows:

A certain amount of iodine is placed in a small bottle with a cork through which two terminals protrude. The bottle is kept, by a suitable method at such a temperature that the substance is deposited as a very thin layer to enable current to flow from the battery through the relay. Then

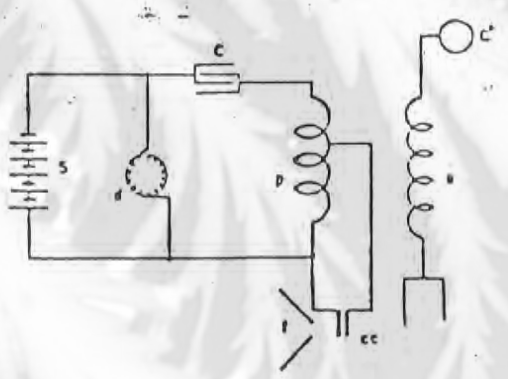
high current could be achieved by suitable connection of the relay whereby the iodine layer would be destroyed and the terminals are isolated in that manner. This process is repeated at the desirable speed. Such a layer could be used to detect weak telegraph impulses through the media, in which case it is necessary to connect the capacitance to the ground also.

June 13, 1899

Transmitting device schematic for a long distance wireless telephone system. The most difficult part is in the practical problem solution, that is the powerful device control with the weak signals which could be produced by the human voice.

One of the best methods is the use of carbon contacts as in a microphone, but then as in this case, high currents or high emf have to be used and that creates considerable difficulties.

The solution I described earlier is given in the shown schematic. S is a current source, the best is a dc current source, as for example, a powerful battery or dynamo. C is a capacitor connected to primary p, and d is the interruptor commonly used in oscillator. Interruptor d is made so that resonance is achieved at a certain number of interruptions.



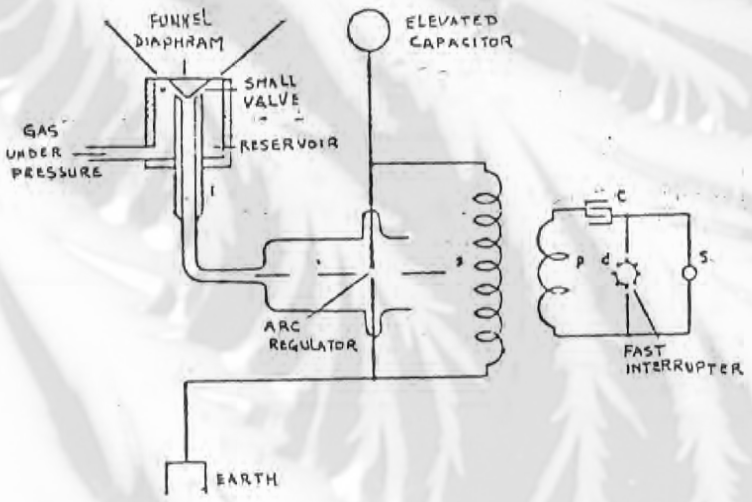
P. 35

Secondary winding s is connected to the ground and to the insulated body, of certain capacitance, which is elevated to a certain elevation as shown, and the adjustment is such that the secondary winding with its capacitance and self-inductance is in the reasonance with primary circuit p. Two contacts cc are connected in parallel with a portion of the

primary. The mentioned contacts are made of carbon. Normally the carbons touch each other very slightly but while talking towards funnel f they will harmonically make better contact, the primary current is changed, the resonance is spoiled and the effect in the secondary circuit is rhythmetically reduced by the voice vibration. In this manner, very small contact resistance variances will produce large viariations in transmitted waves intensity. The number of interruptions of interruptor d has to be considerably above the voice vibration (amplitude modulation).

June 14, 1899

The following device, which was considered in general previously, seems to be particularly suitable for long distance wireless telephone system since for those applications, as well, it is necessary to achieve powerful device control with weak signals, for example, as those produced by a human voice. The idea is to use an ordinary oscillator, supplied from a source of dc current, with an interruptor (mercury or ordinary arcing gap device) which has a much higher frequency than the vibrations of a human voice.



Obviously there has to be an electric arc, either in the primary or in the secondary which can be extinguished, or its resistance can be substantially increased in rhythm with the vibrations caused by a human

voice or in some other way, as may be the case.

P. 36

The control of the electric arc is achieved by a stream of air or some other gas, which emerges under pressure from the opening, the size of which is adjusted by a suitable method using the vibrations. The schematic of such a device is shown in the figure, with the electric arc control placed in the secondary circuit. The source of dc current S charges the capacitor C, and its discharge interruptor (with high number of interruptions) d and primary p excites secondary s, which has a commonly used connection for telegraphy, what I already achieved earlier. Air or gas under pressure is controlled by the diaphragm and valve v. The output tube t could be advanced towards the diaphragm as much as necessary to achieve the best result. In this manner or by some modified method it is possible to control a powerful device with weak vibrations produced by the human voice.

June 15, 1899

Today our first experiments have been performed in the station. The supply transformer emf was only 200 volts. The interruptor on the disk, driven by Kroker-Wileroy motor, has the frequency between 800 and 1200 interruptions per second. It was found that (omega) amounted to approximately 800. Under these conditions, the secondary of the high voltage transformer from New York, could charge only three to four jars, and it was impossible to achieve anything more than harmonic vibrations in the oscillator secondary circuit. Many more jars are therefore required.

The secondary was wound on a cone shaped core with 14 turns and an approximate mean length of 130 ft. The primary was made from one cable winding which was used in New York lab, for the same purpose, and consisted of 37 conductors of No. 9 rubber insulated. The design details I will describe later on.

Remark: Sparks were moving across the lightning arrestors instead of into the ground. Due to that, it was necessary to change to connections to the ground, by separating the oscillator secondary from the lightning arrestor grounding. By connecting the secondary to a water pipe and placing the grounding of the lightning arrestor or protector, as earlier, the sparks disappeared. This indicates that lightning protectors or arrestors were poorly grounded. The latter operated exceptionally good. The grounding was achieved by burying a gas pipe to about 12 ft. and around it carbon briquettes are placed. That is how this is usually done here. The power which has been applied in the first experiments was very small--only 1/2 to 3/4 hp. The spark on the secondary was 5" long, thick and loud. This indicates considerable amount of capacitance in the secondary circuit. The change of spark length in the interruptor

did not cause any particular change. The weather was stormy, it was raining and lightning.

June 16, 1899

The experiments were continued today. Grounding was provided by digging the hole 12 ft. deep and by placing a 20" x 20" copper plate at the bottom covered again by carbon briquettes as usual. The ground was continuously watered to improve the conductivity, but dispite all that, the conductivity was really bad.

P. 37

It is obvious that rocky and dry ground was the reason for this, and I think, that many damages caused by lightning could be explained on the basis of bad grounding conditions. By continuous watering the ground, the resistance between the grounding plate and water pipe system was reduced to 14 ohms. Repeating my connections between the grounding plate and the water pipe system, caused the sparks again to arc across the lightning protector. When the connection with the water pipe system was disconnected, these sparks disappeared again. The action of the waves which propagate through the ground was tested by means of the sensitive device, which I will describe later, and a very powerful vibration was discovered in the ground below and around the laboratory. Intentionally the sensitivity of the device was reduced to perform the comparison with previous similar experiences. The device did not react when positioned in the vicinity of the oscillator, without the ground connection or capacitance, but it reacted at 200 ft. from the laboratory when connected with one terminal to the ground. Also, it reacted along the entire water pipe system, as far as it was possible to reach, although there was a very good ground connection. The influence on the device was powerful even when the arcing on the secondary terminals did not occur? This is a very good indication for researching standing waves in the ground. I concluded that the ground resistance was not too high. It is likely that the ground influences the primary and secondary more than was assumed on the basis of the influence caused by induced currents.

(This has to be tested).

June 17, 1899

The measurement of resistance between the grounding conductor and the water pipes indicated a surprising value of 2960 ohms and after pouring water for half an hour the resistance was still 2400 ohms, but then, after continuous watering it started to drop very quickly. It is obvious that the water was absorbed in the ground and as a rule it was very dry, and therefore it was very difficult to achieve good grounding. This could become a big problem. Grounds will have to be watered continuously. High resistance explains the difficulties which lasted for several days when trying to achieve the desirable secondary oscillations. The first good ground obviously is where the water pipe which supplies the laboratory is connected to the underground supply pipe, and that is several hundred feet away. This increased the secondary wire length which then became too

long for 1/4 of the wave as was calculated. The closest connection to the ground, according to measurements, was approximately 260 ft. away but that was not certain.

The measurement of primary, secondary, and mutual inductance.

The data for two primary windings connected in series were as follows:

$I = 34, \quad E = 7, \quad R = 0.015, \quad W = 716, \quad I = \frac{E}{\sqrt{R^2 + W^2 L^2}}$

By neglecting R^2 we get $WL_p = 0.206$ and $L_p = 287{,}000$ cm (approx.)

P. 38

For a secondary with 14 turns on a coiled frame and with the turns mean length value of 130 ft.

$E = 57.7 \quad E/I = 4.57 \quad W^2L^2 = 16.49 \quad L_s = 4/716 = 0.0056H$ (approx.)

$I = 12.65$

$\omega = 716 \quad \left(\frac{E}{I}\right)^2 = 20.98 \quad \omega L = 4$ (approx.) or $L_s = 5{,}600{,}000$ cm (approx.)

$R = 2.12 \quad R^2 = 4.49$

The co-efficient of mutual inductance of two primary turns in series:

$$M = \frac{E_p}{\omega I_s} = \frac{6 \times 10^9}{716 \times 10.7} = 783{,}300 \text{ cm}$$

Ep = 6
Is = 10.7
ω = 716

This will reduce L. The reduction is estimated from

$$1 - \frac{M^2}{N} = L\left(1 - \frac{M^2}{NL}\right) = L \times 0.64$$

June 18,1899.

The experiments with the oscillator were continued and showed that a suitable oscillation does not obviously occur for some reason which has to be explained. To find out where the disturbance originates, due to weak induction from primary winding, the coil was wound on cylinder 30" in diameter and 10" in length with 500 (approx.) turns of wire No. 26, which was used in some experiments in New York. It was connected to one open secondary terminal, with which amplification was achieved - and current streamers of approx. 12" in length were obtained on the last turn, even at weak secondary excitation. It seems that the disturbance occurs because of internal capacitance. The total length of 1/4 of the wave for the coil

was approximately 2400 ft., which corresponds with the calculation performed on the basis of primary circuit vibration. The experiments with this coil indicate the advantage of an additional coil, as I made it, and as I already noticed when experimenting in New York. In other words the coil is practicaly not inductively linked, thus it is used only for the purpose of increasing the inductive emf.

The secondary inductance measurement: the secondary was made of 12 turns on a cone shaped core, with 1 1/4" distance from center to center of the turns. The results were as follows:

The current through the secondary = 10.9
Emf at the terminals = 74V
ω = 710

From here it was derived L_s = 9,500,000 cm.

P. 39

Data for mutial inductance:

Current through the secondary = 10.9 A

emf on primary (1 turn) = 4.75

ω = 710

This gave $M = E/\omega I$ = 0.00062 H or 620,000 cm.

Compared with the first winding (14 separated turns) the second winding was better due to larger self-inductance and higher co-efficient of mutual inductance.

The measurement of capacitance in sections:

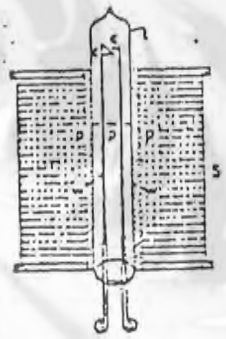
Today the capacitor was compared with a standard of 1/2 mfd by means of the wire bridge and telephone earphone as per Maxwell method. The capacitor has 80 sections, 40 at each side, so they could be connected as desired by means of plugs. Therefore, there are $1 + 2_1 + 2_2 + 5 + 10 + 20 + 30 = 80$

sections in total. Measurement performed today by Mr. L. gave 0.153 mfd per unit.

(This has to be checked)

June 19, 1899

A sensitive automatic device for receiving circuits of telegraph signals through natural media, the purposes of adjustment and so on. The device is shown in a simple shape in the figure below.



In small glass tube t two thin wires ww made of soft iron or steel are attached to platinum contact ends cc. The coil S wound with wire surround the tube t. The contact points are of such shape that the wires could be bent enough but at the same time such that the separation is not too large. When a current flows through coil S wires ww separate and the distance between contact ends cc is increased. The tube is gradually discharged. The dielectric between the ends is stressed to very close to flashover with sensitive powder and a battery and when a signal enters the circuit the dielectric will break down under the increased voltage, so that the current from the battery flows through the coil s, separating the contact ends and thereby interrupting the battery current circuit. In this case the series connection of contact ends cc, coil S and battery is assumed, but the connection could also be made by other methods to achieve the same result--i.e. automatic interruption after the signal is received. Contact ends have to be very close to one another and pointed. The separations ppp exist to limit the wire ww movement and to prevent vibrations after each activation. On coil S the additional coil could be placed for wire adjustment so that the ends are at a necessary small distance, which could be easily achieved by adjustment of the current through an additional coil, and for the signal registration a circuit could be connected, in a suitable way, for an independent relay. The quality of the vacuum could be made variable. In the first device, the coil s had 24 layers with 94 turns in each layer or 2256 turns in total made of #21 wire. The resistance amounted to 14.7 ohms.

P. 41 June 20, 1899

The approximate estimate of some device characteristics. The capacitance with new jars will be approximately 0.174 mfd with two capacitor groups in series as usual. Under the assumption that the transformer supplies 20 kV, the energy per impulse will be $\frac{4 \times 10^8 \times 0.174}{2 \times 10^6} = 34.8$ watts,

roughly estimated.

If we assume 1600 discharges per second through the primary, the capacitors wi output 34.8 x 1600 = 55,680 watts or somewhat more than 74 hp. With 10 kV, the capacitors will still output 74/4 = 18.5 hp. Vibration of the primary will approximately amount to:

$$T = \frac{2\pi}{10^3}\sqrt{\frac{7 \times 10^4}{10^9} \times 0174} = \frac{2\pi}{10^5}\sqrt{0.7 \times 0.174} = \frac{2.2}{10^5} \text{ or } \frac{22}{10^6}$$

this will give approximately n = 45,500 per sec. Such vibrations assume only one turn in the primary.

The wave length is calculated to be approximately 4 miles or 21,120 and $\lambda/4$ = 5280 ft. As each turn has approximately 130 ft., we will need for 1/4 wavelength approximately 5280/130 = 40 turns. Or, if two primaries in series are used with the same capacitance, then the wavelength will be doubled, and therefore 80 turns are necessary. Let's say that 80 turns were used: the self-inductance of the secondary will not be differ much from the value 165 x 10^6 cm. The period of the secondary circu will be

$$T_1 \frac{2\pi}{10^3}\sqrt{\frac{165 \times 10^6}{10^9} \times \frac{38}{9 \times 10^5}}$$

By assuming there is no internal capacitance or that it was avoided by a suitable design and that a sphere of 30" in diameter exists (or approximately 38 cm in radius) at the open terminal and on the secondary. Then will have

$$T_1 = 164/10^7 \text{ and } N = 61{,}000 \text{ approximately.}$$

But this vibration will not be in harmony with the primary vibration. In order to achieve that, secondary self-inductance could be calculated. We have,

$$T = \frac{1}{45{,}500} = \frac{2\pi}{1000}\sqrt{\frac{38}{9 \times 10^5} L_s}$$

where L_s is the secondary inductance we want to calculate.

From here L_s = 10/32 H, or L_s = 312,500,000 cm. Let's assume that the wire is wound on the same core and the length remains as previously-- the required number of turns could be obtained from the equation

$$\frac{165 \times 10^6}{312 \times 10^8} = \frac{6400}{N^2} \quad \text{from here } N^2 = 12{,}102 \text{ and } N = 110 \text{ turn}$$

P. 42

Besides the wire I have available, this will cost $250 but with 80 turns it will cost only $100. to obtain the same secondary vibration, the capacitance at the open terminal has to be increased. The required capacitance C will be:

$$\frac{1}{45,000} = \frac{2\pi}{1000}\sqrt{\frac{165 \times 10^6}{10^9} \cdot C}$$

from here it follows that C = 67.3 cm. The sphere of such size should not be used. By using a disk we will have $2r/\pi = 67.3$ or r = 56 cm. It is difficult to believe that this could be used except at low voltages, the leakage would be too large.

All these estimates, naturally, lead to an assumption that the secondary distributed capacitance is somehow overcome, for example, by means of capacitors in series. It is certain that the secondary circuit vibration will be much slower.

June 21, 1899

Values and device characteristics were continuously considered. The present supply transformers could supply 26 hp.

Let's assume the use of this energy, it is 26 x 750 = 19,500 watts as well as 1,600 interruptions and capacitor charges per sec. That gives for each interruption 19,500/1600 = 12 watts approximately. Let's assume that the surplus of power would be added to this so that the secondary would receive 12 watts net for each discharge in the primary circuit. That means that the capacitor at the end of the secondary will be charged 1600 times per sec. to the potential p.

If C is the capacitance at the open terminal of the secondary, then we will have $12 = (p^2/2)\ C$, and from here $p^2 = 24/C$. Let's take capacitance C as the sphere of 38 cm. in radius. This will give,

$$\frac{24}{38} = p^2 = \frac{9 \times 10^{11} \times 24}{38} \quad \text{and from this}$$

$$p = 3 \times 10^5 \sqrt{\frac{240}{38}} = 3 \times 10^5 \times 2.51 = 753 \text{ kV}$$

Approximate estimate of the primary voltage which is required to achieve the above output power.

In order to achieve the minimum emf. it will be necessary to connect both capacitor groups in parallel. This will provide capacitance of 0.174 x 4 = 0.696 mfd. By designating with p_1 the primary emf., which is required for designated output power, we will have:

$$\frac{0.696 \times p_1^2}{2 \times 10^6} = 12$$

P. 43

From here $p_1^2 = 10^9/29$ or p_1 = 6 kV approximately (at energy of 26 hp. and

1600 interruptions per sec.).

At this emf., if we assume 4 ohms for electric arc resistance, the initial current through the primary would have to be 1500 amps. With these assumptions the loss in the primary could be calculated.

June 22,1899.

It is necessary to order a new secondary winding made of rubber insulated wire #10 B & S, at Habirsoa, 11,000 ft. in total (more exactly 10,500'). That will be enough for 80 turns with mean length 131 ft. each.

#10 American standard or 5.26 mm^2 or 5.26/645 $in.^2$

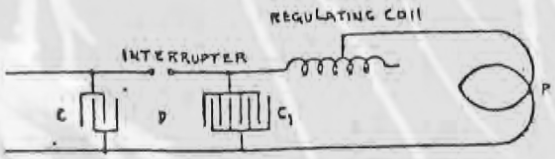
100 feet will have (5.26 x 1200)/645 = 9.8 $in.^3$

The weight of this, when taken into account 5.13 $oz./in.^3$, will amount to

$$\frac{5.13}{16} \times 9.8 = 3.14 \text{ lb.}$$

Therefore, 11,000 ft. will weight 345.4 lb. That means that there will be less copper in the secondary than in the two primary turns. With double conductors in the secondary, we will have 40 turns and with 4 times as many (for fast vibration) 20 turns. The copper weight will remain the same and some of the #10 wire can be used for first lower turns.

Some schematics were tested for the purpose of prolonging the vibration in the primary circuit after each interruption. One of those is shown in figure below.



Capacitor C_1 was connected in parallel with primary P. As in this circuit, there was no arcing device, the overvoltage factor was very high, while the resistance was negligible, vibration was maintained much longer after each interruption, then would be the case if the usual wiring diagram is used. The sharpness of adjustment is a very interesting event. It seems that that originates from the fact that there are 2 circuits or 2 separated vibrations which have to correspond to one another exactly. The sparks were powerful at the secondary terminals wheever $C = aC_1$, where a

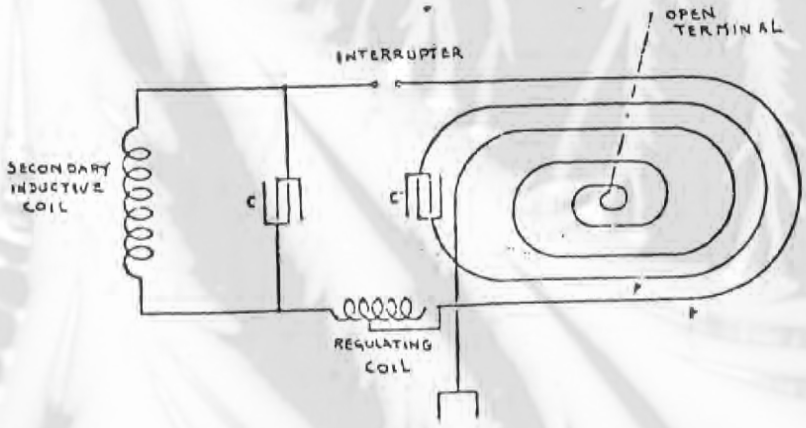
is a whole number (not a fraction) and particularly when a = 2 or 4.

Such a connection was performed in New York with one of the latest oscillators and the similar results were observed.

P. 44

By using this method and there were losses in circuit p, because this portion does not act on the secondary which is an inductive link with P. The change was in having one or more primary P turns or independent turns in circuit p. The mentioned turns acted inductively on the secondary.

One device which is intended for the same purpose was tested as well. It consisted of the application of 2 primaries, of which one was independent from the interruptor and bridged over by a capacitor, as shown on the figure:



This was tested in New York as well and it was found that the device is good when the number of interruptions are small. When the interruptions are fast, there is no difference. When adjusting, $C_1 p_1$ was initially adjusted to vibration CP and the secondary was adjusted afterwards.

This has to be continued.

June 23,1899.

Approximate self-inductance of the regulating coil brought in from New York which ought to be used in the primary circuit.

Dimensions: cylinder diameter 12" = 30.48 cm.

cylinder length 18" = 45.72 cm.

number of turns: 24

The area which will be enclosed by one turn $\frac{\pi}{4} d^2 = 730\ cm^2$. From this we find $L = \frac{4\pi N^2 S}{l} = \frac{12.57 \times 576 \times 730}{45.72}$ cm = 115,600 cm.

Therefore, for the approximate value we have 115,600/24 = 4800 cm/turn.

This will be too much because the turns are separated and thick. According to Lanzvenovoj equation $L_s = \frac{L^2}{l}$.

Here L is the total wire length, it is 30.5 x 3.1416 x 24 = 2300 cm. approx.

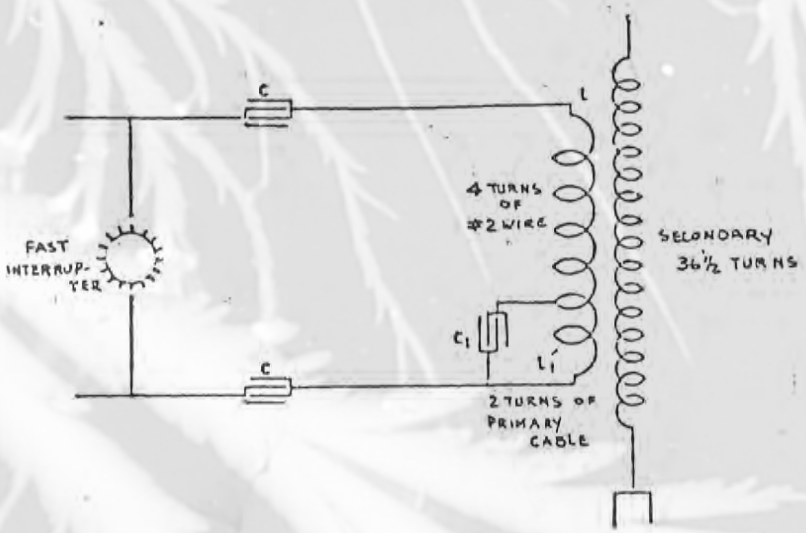
P. 45

This will give the value $L' = (2300)^2/45.72$

$L' = 115{,}700$ cm, obviously close to the previously calculated value.

The experiments with the oscillator secondary with 36 1/2 turns were continued. A number of modified schemes with auxiliary capacitor were tested--one of those is shown in the figure below. All of these experiments had the main purpose of prolonging the vibrations in the primary after each interruption as well as achieving a sharper reasonance in the circuit.

By using the auxiliary capacitor, I achieved 2 circuits without the arcing device. In these circuits the damping factor was unusually small and overvoltage factor very high.



In order to get the best results it was necessary to achieve the ratio

$$\frac{C}{2} L = C_1 L_1 \quad \text{and with } L_1 = \frac{L}{4} \text{ we get } C_1 = \frac{4C}{2}.$$

The reasonance was achieved by means of 15 jars on each side of the primary made of 6½ turns. With 4 turns in the primary 15 x 36/16 = 34 jars were required. With one thick conductor 68 jars would be required. (further consideration).

Remark: Several vibrations were tested with such connections. In some of them the sharpness of adjustment was very evident; one turn of the regulating coil was sufficient to destroy the action, or to cause a high increase in the maximum voltage. The jars frequently flashed over due to this fast voltage rise during the regulating coil handle rotation.

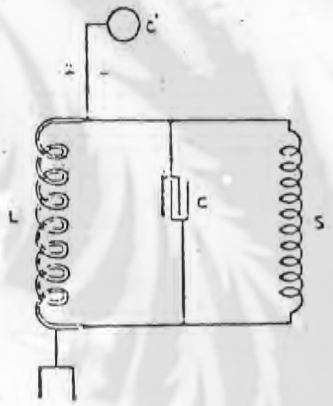
June 24,1899.

The following plan for obtaining an electrical circuit of exceptionally small resistance, suitable for reasonant circuits and other applications offers the possibility of achieving results which otherwise could not be achieved. This plan is based on the observation that with discharges of sufficient intensity and high frequency through a rare gas the resistance of the gas could be reduced so as to fall considerably below the resistance of the best conductors.

P. 46

Therefore, through the balloon with rare gas in it, huge amounts of energy can pass through, or the maximum current could pass through a rare gas, which would not pass through a copper conductor, due to its resistance and impedance. The plan is now to make the circuit which contains the rare gas cylinder, which is heated to a very high red hot level, which will offer unbelievably small resistance to the current, and to use this rare gas cylinder for this suitable purpose. For the purpose of illustrating this application, for example, for telegraphy, the diagram is given on which S designates the ac current source, preferably of high frequency, C capacitor in parallel with it, and L bent glass tube with rare gas which is kept at high, red hot temperature. The conductor L is connected, as in my system, to the ground and to the capacitance, which has to be at a higher elevation, so that currents from the remote transmitter could pass through. The mentioned currents have to be of the same frequency and cause high emf. rise at the terminals of conductor L, which could be used in a number of ways to act on the receiving device.

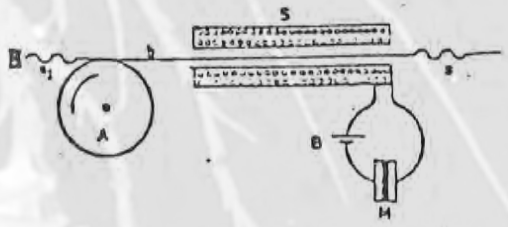
(to be continued).



June 25,1899.

The following plan is suitable for amplifying small changes which occur for example with a microphone. Let's assume that on one rotating, or generally speaking, moving smooth or polished iron surface there is a brush made of soft iron steel or coated by any magnetic material. A certain friction will occur between surfaces of the brush and the moving surface and brush will be pulled towards the moving surface. The spring could be used to return the brush back in the opposite direction of the friction force and to maintain it in the sensitive balance position. If the brush or the surface is neglegibly magnitized, the friction between magnitized surfaces will be

considerably increased and the brush will be pulled by a large force. Small changes in the surface magnitization will cause such a large change in the force which acts on the brush, and its movement could be used for various purposes, for example, in telephones with amplified sound or for the improvement of "wireless telephone," or something similar. The simple device is shown in the figure:



The A is a cylinder with a smooth iron surface, if not entirely made of iron which is quickly rotated; b is a small rod or brush which touches the cylinder, also made of soft iron. The differential spring $s_1 s$ keeps the light plate or rod in a balanced position, so it presses slightly on cylinder A. S is solenoid which receives the energy from battery B in series with a microphone M. When one talks into the microphone the brush b will vibrate, and its movement could control each device, as for example, the valve or another microphone.

P. 47 June 26, 1899

In the following, the old idea of gas separation, will be applied with a high emf. on the following device using a new oscillator.

Three tubes, t_1 t_2 t_3 (it is assumed that only 3 are required) are inserted concentrically so that they don't touch each other, because of isolating parts a b c. In these isolating parts output tubes A B C are for the purpose of piping various gases into reservoirs where they could be pressurized.



Remark: For this device it is preferable to use the type of oscillator with a mercury interruptor, which is fed by dc current, so that the stress on T would be, generally speaking, in one direction. Any other generator with sufficient emf. will give the same results.

It is understandable that as the tubes produce output there will have to be a required suction, or the mixture will be under a desired pressure. High voltage terminal T is an insulating part P which is attached to the widest tube t_1.

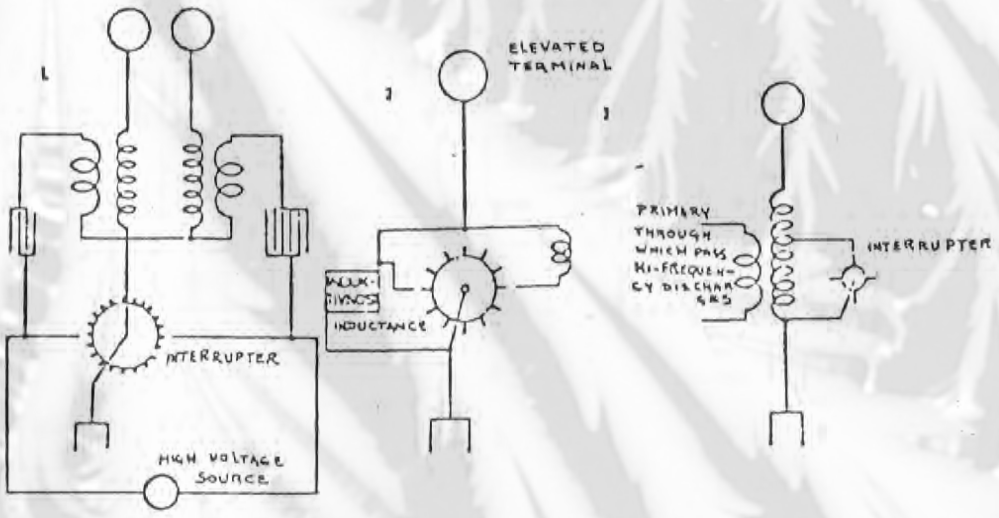
The particles of gas which contacts the active end are strongly pushed and the distance to which they will be forced depends on their size and weight--hydrogen will be thrown further than other gases. This latter element, if it exists, will pass therefore mainly through tube A, while several larger molecules will pass through other tubes. By letting a gas pass through the device again, the desirable level of purity or separation will be achieved.

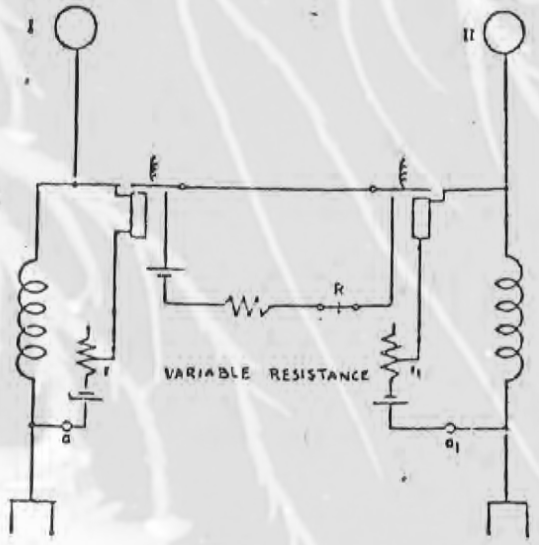
The wiring schematic for the device for telegraphy through natural media without a mediator and according to the method which was tested in New York. The method is not as good as the capacitor method for the individual impulse transmitting, however high reliability could be achieved. The idea is to use a number of synchronized circuits and to make a receiver which depends on the number of such circuits. The experiments indicated that a high level of reliability could be achieved with 2 circuits. I think it is impossible to disturb the receiver with 3 circuits if the vibrations do not have common harmonics very close to the base frequency.

June 27,1899.

P. 48

Some devices which were tested experimentally are shown in the diagrams below. This has to be continued.





Figures 1, 2, 3 show the device at the transmitting station by which 2 vibrations are achieved for different levels. Not all circuits are shown to keep the diagrams simple. In case 1, two transmitting circuits, which have to be at a certain distance, were excited with alternating capacitor discharges of suitable capacitance through the corresponding primaries. In figures 2 and 3, one transmitting circuit is adjusted so that its period changes by inserting the certain inductance as in Figure 2, or by periodical short circuiting of one portion of the circuit with some automatic device. Such a device, however, is not necessary, and the assembly of that kind of interrupter I will describe later on. In the receiving station,2 synchronized circuits will react to the vibrations of the transmitter, each circuit to one of them. The receiver R reacts only when both circuits I ad II move senstive devices a and a_1. The diagrams explain that by themselves.

P. 49 June 28, 1899

An approximate estimate of a secondary of 20 turns on the coil frame, about which I have talked previously and on the basis of the secondary with 36 turns on the same frame. On the latter secondary, the wire was wound on each third groove and on the first secondary on each seventh groove.

Roughly estimated, the capacitance of the secondary with 20 turns, if capacitance of secondary with 36 turns is designated by C will be:

$$C_1 = \frac{20}{36} \times \frac{3}{7} C = \frac{5}{21} C$$

and self-induction L_1 of the secondary with 20 turns compared with L

secondary of 36 turns, will be:

$$L_1 = \left(\frac{20}{36}\right)^2 \times \frac{36 \times 3}{20 \times 7} \qquad L = \qquad \text{As } L = 383 \times 10^5 \qquad C = 1{,}200 \text{ cm.}$$

Therefore,

$$C_1 = 5/21 \times 1200 = 290 \text{ cm. and } L_1 = \frac{383 \times 675 \times 10^5}{2835} = 9 \times 10^6 \text{ cm.}$$

From here $T = \frac{2\pi}{10^3} \sqrt{\frac{290}{9 \times 10^5} \times \frac{9 \times 10^6}{10^9}} = \frac{107}{10^7}$ oscillation periods of second system (approx.)

or $n = \frac{10^7}{107} = 93{,}458/\text{sec.}$

Now the wire length for 20 turns with approx. 139 feet/turn would be 139 x 20 ft.

That gives λ = 11,120 ft. or $\frac{\lambda}{4}$ = 2,780 ft. which will correspond approximately to n = 90,000 per sec.

The sphere, of 38 cm. capacitance added would give the total capacitance

$$290 + 38 = 328, \quad \sqrt{328} = 18.11 \quad \sqrt{290} = 17 \text{ approx.}$$

Therefore, by the sphere addition, the secondary vibration will be reduced to a 17/18.11 portion, which is approx. 17/18.11 x 93,460 = 88,000. That would be too fast a vibration to be suitable for the device, because we would have only 4 jars on each side of the primary.

With an additional coil of 1,500 cm. capacitance, added in series with the secondary at the open end, the capacitance in total will be 1,500 + 290 = 1790; this is approx. 6 times larger than previously. The vibration will then be slower by approximately $\sqrt{6}$ = 2.5 times; it is 37,400/second. This is better.

P. 50 June 29, 1899

The first good test with a newly wound secondary with 36 turns was performed today. The wire was #10, stranded; the turns were wound in every third groove. The conductor separation was approximately 1 7/8".

The vibration conditions of first experiments:

The approximate secondary self-inductance is 5×10^7 cm. The additional coil was connected to the open end of the secondary, while it had 240 turns on the core 6' in length and 2' in diameter. Rougly estimated coil self-inductance is 10^7 cm. A = 2900 cm^2, N = 240 turns, l = 183 cm.

$$l = \frac{2900 \times 240^2 \times 2}{183} = 114 \times 10^5 \text{ for the rough estimate} = 10^7$$

The wavelength would be (by neglecting the capacitance):

$4 \times [5280 \text{ (secondary)} + 1440 \text{ (coil)}] = 4 \times 6720 = 26{,}880'$ or approx. 5 miles.

In order to achieve this wavelength, the actual primary frequency has to amount to 187,000/5 = 37,400/sec. (the same value was obtained previously).

The primary capacitance C_p is found from:

$$\frac{1}{37{,}400} = \frac{2\pi}{1000}\sqrt{LC_p} = \frac{2\pi}{10^3}\sqrt{\frac{7 \times 10^4 \times Cp}{10^9}}$$

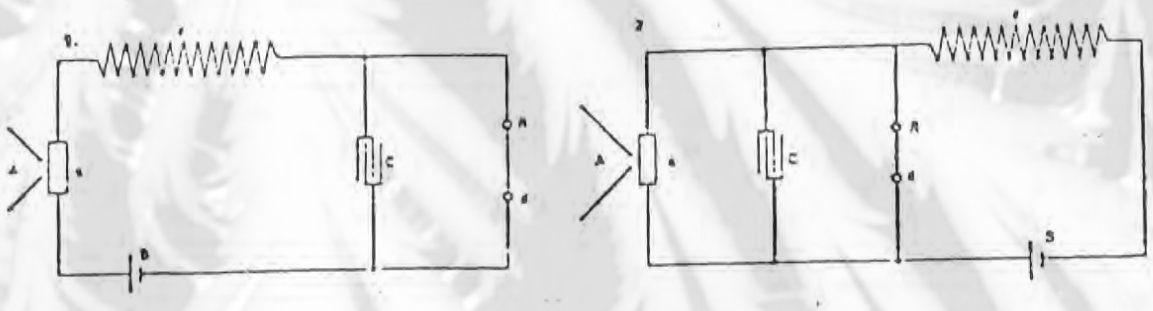
$$\frac{1}{374} = \frac{2\pi}{10^3} \times 0.84\sqrt{Cp},$$

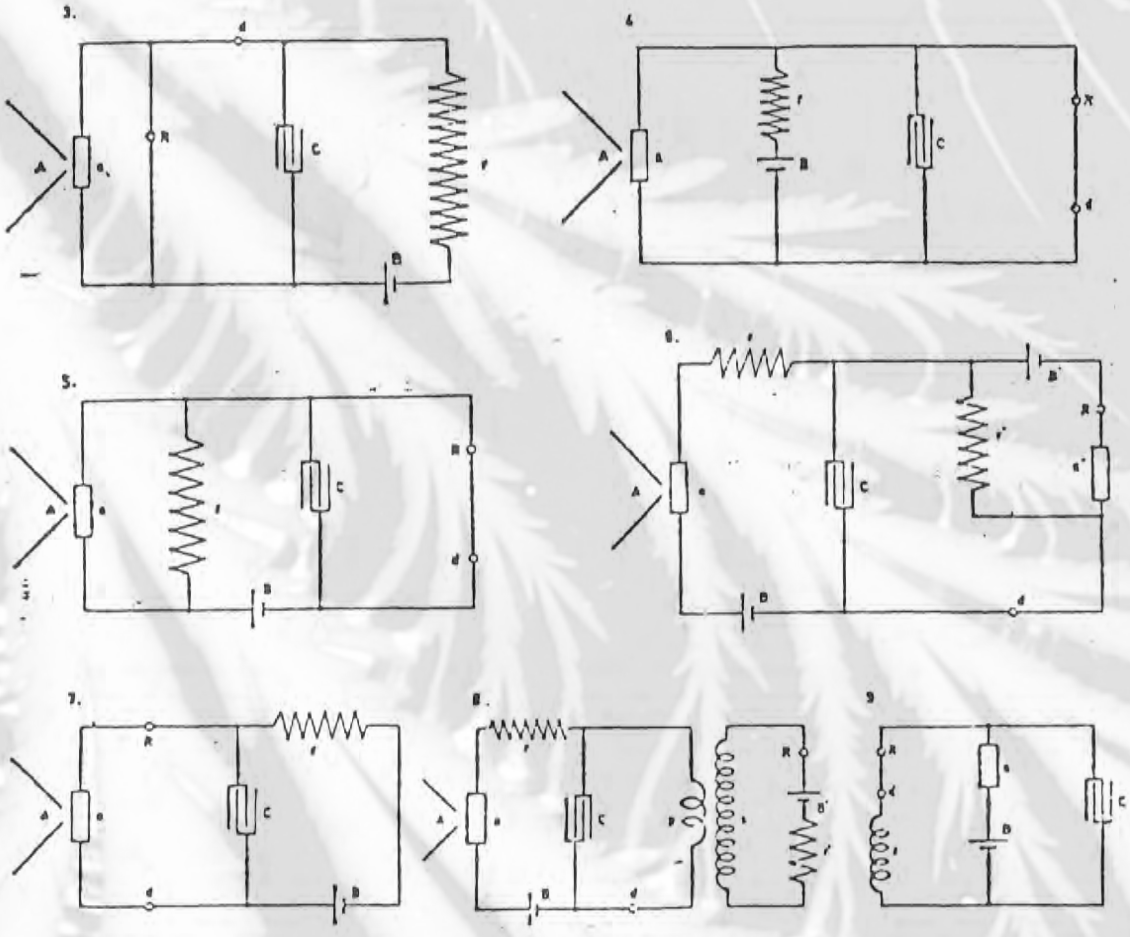
$$\sqrt{Cp} = \frac{10^3}{2\pi \times 0.84 \times 374} = \frac{1000}{1975} \text{ or approx. } 0.5$$

$$Cp = 0.7 \text{ mfd.}$$

Thiw will require 0.7/0.003 jars = 233 jars with 2 primary windings in parallel, or 233/4 or approx. 58 jars with 2 primaries in series in total. Because so many jars were not available, it was obvious that only higher vibrations could be achieved. This explains why the first results were not satisfactory.

The wiring schematic of the device for the capacitor method which was the equipment subject




3.
4.
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9.

P. 51 June 30, 1899

Simple equations which are used for the purpose of a rough estimate of frequently required values.

In equation $T = \frac{2\pi}{10^3}\sqrt{LC}$, L is in ft. entries, but usually it is required in

Due to that we can take

$$T_1 = \frac{2\pi}{10^3 \times 10^4 \sqrt{10}}\sqrt{LC} \quad \text{or approx. when L is in cm.}$$

$$T_1 = \frac{2}{10^7}\sqrt{LC} \quad \text{where C is in mfd 1)}$$

From the equation $L = \frac{T_1^2 \times 10^{14}}{4C}$ we have

$$C = \frac{T_1^2 \times 10^4}{4L} \quad \text{. 2)}$$

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Expressing C by means of number of jars, where $C = n \times 0.003$

we get $n = \frac{T_1^2 \times 10^{17}}{12L}$ 3)

by introducing λ again in miles instead of T_1, and because

$$T_1 = \frac{\lambda}{187{,}000}$$

we get $\lambda = \frac{374}{10^4}\sqrt{LC}$ or, because usually $\lambda/4$ is required

$$\frac{\lambda}{4} = \frac{93.5}{10^4}\sqrt{LC}$$

The observations made while experimenting with oscillators with 36 1/2 turns and an additional coil:

An additional coil, as observed with the device in New York, represents an excellent way to achieve a very high emf. But it is unusual for the suitable development of independent coil vibration, that its torque has to be very high in relationship to both when the relationship is such that tree vibrations occur easily and more obviously. But, if the imposed torque is very high while the coils torque is small, then the free vibrations could not be established easily by themselves. That is the same as in Mechanical Engineering. The pendulum is disturbed and the impossed torque will dominate more or less. I differentiate this fromthe amplification factor which depends on pL/R.

It was obvious to me that to achieve the best result, it will be necessary to have "free" vibrations, when an additional coil is excited this way: coil vibration, secondary vibration and vibration of the combined system are the same. Bearing this in mind, it is useful to insert the inductance between the secondary and the additional coil, to make the additional coil free when the imposed vibration is too strong to allow the occurrence of the required coil vibration immediately.

It appeared from the experiment that it would be useful to have some self-inductance in the circuit of the interrupting device in the primary.

(This has to be checked). The use of a capacitor in series with the supply secondary, is sometimes useful, but very little when the secondary vibration is in resonance with the primary. Then the short circuiting of the supply transformer is less frequent and the spark-overs are loud and sharp.

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and believe that their work will not fail to have due influence on similarly situated companies this side of the border.

MR. TESLA ON ROENTGEN RAYS.

LAST week Mr. Tesla gave some of the results of his experiments in the domain of Röntgen rays, before the New York Academy of Sciences, and showed some of his latest types of high frequency generators. Mr. Tesla still adheres to his original view that the Röntgen effects are due to the action of molecules projected from the tube at high velocities, but we must confess our inability to reconcile this view with the results of his experiments in deflecting the Röntgen rays by means of a magnet, unless we assume the molecules charged and at the same time endowed with a vortical motion, a point which Mr. Tesla did not elaborate on. It is so rarely that Mr. Tesla appears on the lecture platform that it is to be regretted that the conditions surrounding his last appearance were not more favorable. It was hardly fair to Mr. Tesla, or to the large audience which had assembled solely to greet him, to delay his appearance until two other estimable speakers had taken up the time of the audience for nearly three-quarters of an hour. The result was that it was close on to 10 o'clock before Mr. Tesla began, and he was forced to conclude his address in its initial stages. It is to be hoped, for the benefit of the science at large that Mr. Tesla will find time to write out his address in full for the Transactions of the Academy. Brief as his utterances were, they were extremely interesting and they evidenced a mellowing and a mastery indicative of higher perfection than ever of his powers as an investigator and elucidator of obscure natural phenomena.

VIEWS OF THE TARIFF

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...not stop the rays which produce harm.

...to be known to say that the effect is ...to be another electro-static, nor magnetic, but merely a ...of certain rays reaching the skin surface, and such rays ...probably those of the Röntgen rays not readily absorbed. ...ording to the law of inverse squares an exposure of 12 ...utes at ¼ inch distance would require, at 10 inches dis... ...for equal effects, about 50 hours, or over two days. ...is, then, no occasion for any alarm at the effects of ...gen rays, as exposures of sufficient duration to produce ...n are rarely if ever necessary.

...regard to the claim which has been made that injury ...ly follows exposures made by induction coils, while static ...chines do not produce the effect, it may be said that in the ...ter's former experiment, of which the little finger was ...ade the subject, a large capacity static machine was used, ...d the result was severe enough. The present experiment ...as made with an induction coil as the source of electric dis... ...charges, and as yet there is no difference in the results. The ...ffect is now, of course, limited to two small spots a little ...distance apart.

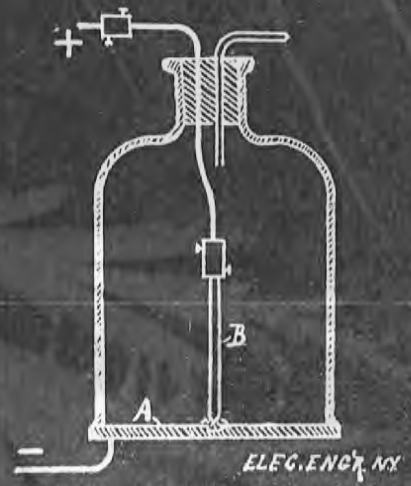
MR. TESLA BEFORE THE NEW YORK ACADEMY OF SCIENCES.

On April 6, Mr. Nikola Tesla delivered before the New York Academy of Sciences an address "On the Streams of ...ard and Röntgen, with Novel Apparatus for Their Produc... ...The lecturer began by stating that in 1894, in experi... ...ing to determine the actinic action of phosphorescent ...ght emanating from vacuum tubes, he had found that the actinic power of Crookes tubes varied greatly, and in the most anomalous manner. Thus some tubes emitting a strong light had very little action on photographic plates, while some showing a feeble light acted very strongly on such plates. A large number of these plates, made by Tonnele for the Century Magazine, were stored in Mr. Tesla's laboratory when it was destroyed by fire, and thus he was unable now to examine them for the Röntgen effects. He believed that he had just missed the discovery which made Röntgen famous and though he was thoroughly familiar with Lenard's work, he did not see far enough.

Mr. Tesla then reviewed his work in the direction of obtain...

...ing a reliable apparatus for generating high frequency cu... ...rents, which he recognized as the keynote to the productio... ...of vacuum tube lighting. He told how he had met with dif... ...culties at every point; how a small bubble of air would d... ...stroy the value of the coil, or how one-quarter of an inch wire too much or too little would throw a coil out of balanc... ...how one day a coil would run cold and on another day ho... ...etc. By finally calling to his aid the condenser, Mr. Tesl... ...stated, he had succeeded in obtaining the desired action an... ...now nothing stood in the way of securing millions of vibra... ...tions from ordinary circuits. The lecturer then briefly e... ...plained the principle of the condenser discharge as applied high frequency currents, and pointed to various types of a... ...paratus on the lecture table designed to utilize the principle.

In order to demonstrate the action of the high frequenc... ...currents Mr. Tesla attached a circular loop of heavy coppe... ...wire to the terminals of a high frequency generator an...



TESLA'S ARC X-RAY GENERATOR.

...brought to brilliant incandescence a small lamp connect... ...diametrically across the heavy loop; the illumination of t... ...lamp could be varied by connecting it to various points the diameter of the loop. Mr. Tesla also lit the lamp by t... ...current induced in a second loop brought in proximity to t... ...first. He explained that the coil accomplishing this wo... ...had a resistance of 600 ohms and an inductance of 6 henry... ...the coil was connected to the circuit one-half the time an... ...took from the primary circuit only 5 watts.

Mr. Tesla next showed a vacuum tube lit from the termina... ...of another high frequency machine. He also showed a co... ...consisting of a single turn of heavy wire which formed th... ...core, as it were, of a small coil of a few turns wound on paper cylinder surrounding the heavy wire. When connecte... ...to a high frequency generator, this apparatus gave a 4-inc... ...spark with an expenditure of energy equal to that taken b... ...one lamp. Mr. Tesla stated that his high frequency gener... ...tors were so constructed that they could be connected to an... ...existing circuits, direct or alternating.

Returning to the Röntgen rays, the lecturer stated that h... ...had succeeded in discovering a new source of these rays, f... ...more powerful than any heretofore available, though the di... ...ficulty of maintaining it was very great. This new source the electric arc; not the ordinary arc, however. The arc re... ...quired for the purpose is that maintained between a platinu... ...terminal and an aluminum plate, as illustrated in the accom... ...panying diagram, where A represents the aluminum plate an... ...B the platinum, enclosed in a glass jar.

Mr. Tesla stated that he had also succeeded in deflectin... ...the Röntgen rays by a magnet. He had proved this by de... ...flecting the rays into a condenser placed a long distance fro... ...the source of the rays, and which in 5 seconds was charge... ...sufficiently to throw a galvanometer needle off the scale.

ONE of the longest electrical patents ever issued has been granted to Mr. Thaddeus Cahill, of New York. It includes 175 claims for the electrical production and distribution of musical sounds. The apparatus is wholly electrical and

His operas are among his best known works; *Four Saints in Three Acts* (1928) and *The Mother of Us All* (1947) boast libretti by Thomson's close friend, the poet Gertrude Stein (*q.v.*). A later opera was *Lord Byron* (1968). His instrumental music includes two symphonies, several symphonic poems, and concerti for flute and cello (composed 1954; 1950). He also composed songs, choral works, chamber music, piano pieces, and film music. He was music critic for the New York *Herald Tribune* (1940–54) and published several collections of penetrating, perceptive critical articles. His autobiography, *Virgil Thomson*, was published in 1966.
·music for films 12:667g
·operas to Stein texts 13:593b

Thomson, William (19th-century scientist): *see* Kelvin, William Thomson, Lord.

Thomson atomic model, earliest theoretical description of the inner structure of atoms, proposed about 1900 by Lord Kelvin and strongly supported by Sir Joseph John Thomson, who had discovered (1897) the electron, a negatively charged part of every atom. Though several alternative models were advanced in the 1900s by Lord Kelvin and others, Thomson held that atoms are uniform spheres of positively charged matter in which electrons are embedded. Popularly known as the plum-pudding model, it had to be abandoned (1911) on both theoretical and experimental grounds in favour of the Rutherford atomic model.
·development and shortcomings 2:336a

Thomson compass, a light mariner's compass invented by William Thomson (Lord Kelvin) in 1876.
·design and advantages 4:1041b

Thomson effect, the evolution or absorption of heat when electric current passes through a circuit composed of a single material that has a temperature difference between two points along its length. This transfer of heat is superimposed on the common production of heat by currents flowing through conductors because of their electrical resistance. If a copper wire carrying a steady electric current is subjected to external heating at a short section while the rest remains cooler, heat is absorbed from the copper as the conventional current approaches the hot point, and heat is transferred to the copper just beyond the hot point. This effect was discovered (1854) by the British physicist William Thomson (Lord Kelvin).
Major ref. 6:579f
·thermoelectric effects in solids 18:316a

thomsonite (mineral): *see* natrolite.

Thomson scattering, the scattering of electromagnetic radiation by free or loosely bound electrons.
·discovery and principles 6:662g

Thon Buri, former province (*changwat*), south central Thailand, occupying an area of 175 sq mi (450 sq km), with a coastline on the Gulf of Thailand. It is drained by the Mae Nam (river) Chao Phraya and numerous canals (*khlongs*), many of which have "floating villages." Rice is the main crop, and fruit is widely grown for market. Apart from Thon Buri (the provincial capital), the main towns are Taling Chan and Bang Khun Thian.

On the west bank of the Chao Phraya opposite Bangkok, Thon Buri city was the national capital from 1767 to 1782. It is now a suburb of Bangkok, the current capital to which it is linked by three bridges. In 1972 Thon Buri and Bangkok were merged into one city-province called Bangkok-Thon Buri metropolis. It is a light manufacturing centre, with rice [illegible] Fruit is grown in the outskirts.

[illegible] of Wat Arun (Temple [illegible] Thon Buri city's best known structure. It is also the site of a naval academy and several hospitals. Educational facilities include Mahidol University and the Thonburi Technical Institute. Thon Buri's railway station is the terminus of the line from Malaysia. Pop. (1970) city, 628,015.
·capital founding and location advantages 16:721c
·map, Thailand 18:198

Thonet, Michael (b. July 2, 1796, Boppard, West Germany—d. March 3, 1871, Vienna), pioneer in the industrialization of furniture manufacture, whose experiments in the production of bentwood furniture widely influenced contemporary and modern styles and whose chairs, still made today, were the work of a functionalist genius esteemed by eminent modern designers.

A humble artisan who set up his own workshop specializing in parquetry (1819), Thonet began in 1830 to experiment with new cabinetmaking techniques. He developed a system of steambent veneers and glued four or five together, from which he made complete chairs that were light and curvilinear. Similar but less free techniques were in use at the time in New York City by the German-born furniture maker John Henry Belter.

Thonet's inventiveness attracted the attention of Richard Metternich, who in 1842 invited Thonet to settle in Vienna; for the next five years he worked on the Neorococo interiors of the Liechtenstein Palace. Some of his work there included bent, solid wood, formed by methods familiar to wheelwrights; these pieces were subcontracted through the firm of Carl Leistler and Son, then decorating the palace, with whom Thonet had gone into partnership (dissolved in 1849).

His representative works shown at the Great Exhibition, London (1851), were a huge success. In 1853 he incorporated with his sons, renaming his firm Gebrüder Thonet. By 1856 he had perfected the bending by heat of solid beechwood into curvilinear shapes, and he was ready for mass production, exporting as far as South America. Factories were later established in Hungary and Moravia. Catapulting to success, he opened salons throughout Europe (including Moscow) and in the U.S. (New York City and Chicago). By 1870 his Viennese firm was producing furniture in hitherto unheard-of quantities—some 400,000 pieces annually. After his death the enterprise was conducted by his sons, who continued to open more factories.

Among Thonet's most popular designs were those of café chairs, rocking chairs, and hat stands. His solid bentwood furniture, never out of production, was again made fashionable in the 1920s by the renowned modern architect and designer Le Corbusier. The utilitarian chairs, mass produced at low prices, were seen all over the Western world and shown in the paintings of such artists as the French artist Toulouse-Lautrec and the U.S. artist John Sloan. Interest in Art Nouveau in the 1960s accounted for still another revival of Thonet's bentwood furniture.
·bentwood furniture manufacture 7:804b; illus. 788

Thonga (African people): *see* Tsonga.

Thonon-les-Bains, town, Haute-Savoie *département*, southeastern France, on a lacustrine terrace overlooking the southern shore of Lake Geneva near the mouth of the Dranse River. It was the capital of the historic district of Chablais. The site was occupied by the Romans and later by the Burgundians, and during the Wars of Religion in the 16th century it was fought over by the Bernese and the Duke of Savoy. In the Place du Château, site of a fortified château built by the dukes of Savoy and destroyed by the Duke in 1589, is a statue of Gen. Jean [illegible] who organized and led [illegible] during the Revolution. The church of Saint-Hippolyte, decorated in 17th-century style, has a 12th-century crypt and a 13th-century font embellished with the arms of the House of Savoy. Attached to it is a modern, neo-Gothic basilica dedicated to St. Francis of Sales, who conducted missionary work in the vicinity and was responsible for the renunciation of Protestantism by the inhabitants of Chablais at the end of the 16th century. A museum in the Château de Sonnaz contains exhibits devoted to the prehistoric Lake Dwellers, as well as a hydrological model of Lake Geneva. Thonon-les-Bains is a popular summer resort, much frequented for its mineral springs. The town is also a centre for trade in cheeses. In addition to metallurgical industries, there are factories producing plumbing fixtures, bicycle parts, electrical apparatus, paper, cigarettes, and food products. A government fish hatchery produces trout, salmon, and char used to stock Lake Geneva and the rivers and lakes of the *département*. A funicular railway runs from the lake shore to the town. Pop. (latest census) 20,095.
46°22′ N, 6°29′ E

Thöny, Eduard (1866–1950), German painter and caricaturist.
·Prussian officer depiction 3:913e

Thor, deity common to all the early Germanic peoples, a great warrior represented as a red-bearded, middle-aged man of enormous strength, an implacable foe to the harmful race of giants but benevolent toward mankind. His figure was generally secondary to that of the god Odin, who in some traditions was his father. But in Iceland, and perhaps among all northern peoples except the royal families, he was apparently worshipped more than any other god. There is evidence that a corresponding deity named Thunor, or Thonar, was worshipped in England and on the Continent, but little is known about him. Thor's name was the Germanic word for thunder, and it was the thunderbolt that was represented by his hammer, the attribute most commonly associated with him. The hammer, Mjollnir (*q.v.*), had many marvellous qualities, including that of returning to the thrower like a boomerang; it is frequently carved on runic stones and funerary stelae.

Among Thor's chief enemies was the world serpent Jörmungand (Jörmungandr), symbol of evil, who surrounded the world. Tradition-



Thor with his hammer, Mjollnir, on a bronze statuette from Iceland, 10th–11th century
Reykjavik

photographs, negatives, VHS tapes, cassette tapes, 35 mm slides, and microfilm. The collection contains 49 boxes and has been arranged into 8 series: I. Contextual/Biographical about Tesla; II. Leland Anderson's Research; III. Topical; IV. Biographical Materials, Tesla's Contemporaries; V. Tesla's Patents and Inventions; VI. Scholars Files; VII. Journals and Publications; VIII. Audio/Materials.

Series I. Contextual / Biographical about Tesla

Series one contains contextual material on the life of Nikola Tesla, primarily contained in secondary publications concerning different facets of his life and work.

Box 1 Scrapbooks created by Leland Anderson containing newspaper clippings, articles, and photocopied materials about Tesla, photocopies of letters to and from Tesla concerning his work and discoveries (1900s-1940s), and articles on Tesla and his contemporaries.

Box 2 2 Scrapbooks of published articles concerning Tesla's theories and works, from 1943 through 1961, and the 1970s. There are also three folders of assorted biographical materials concerning Tesla, including correspondence to and from Tesla and copies of agreements with Westinghouse.

Box 3 3 Scrapbooks containing newspaper clippings, articles, and assorted photocopied biographical materials

Box 4 Biographical material on Tesla, primarily copies and chapter excerpts from different works. There is an original manuscript of John Jay O'Neil's biography on Tesla, *Prodigal Genius*.

Box 5 Contextual materials about the life and times of Nikola Tesla including writings about him, articles about his life, interests, and ideas, as well as theories he was connected with.

Box 6 Contextual information, primarily copies of authors' papers, news clippings, magazines, and research concerning topics such as Tesla's death, Tesla and extra terrestrial communication, Tesla's family, his patron saint, spirituality, social acquaintances, and musings on his personal philosophy.

Box 7 Photocopied materials featuring Tesla's writings for various publications and addresses to the New York Academy of Science, NY Electrical Society, and others. There is also photocopied correspondence with colleagues and relatives (1880-1942) that was translated by staff from the Tesla Museum in Belgrade. There is a box level inventory inside this box.

Series II. Leland Anderson's Research

Series two consists of copies of archival and library materials from a number of institutions, as well as published materials on Tesla's life or his work, which were used by Anderson in compiling his writings about the man.

Box 8 Primarily photocopied archives materials, including copies from the Marie Scherff Collections at Columbia University, all on Tesla's life and work. Marie Scherff's father, George Scherff, was Tesla's trusted assistant. Box 8 also includes Library of Congress (LOC) copies of correspondence between Tesla and Mark Twain (1892-1910), Westinghouse Electric and Manufacturing Company (1888-1899), and John Pierpont Morgan (1907-1943).

Box 9 Photocopied archival material, primarily from the LOC, of correspondence between the Westinghouse Company, Tesla, George Scherff, and others. There is additional material from other institutions.

Box 10 Primarily contains copies of Columbia University correspondence between Tesla and Robert Underwood Johnson, or between Johnson and others concerning Tesla. Johnson was an author, editor of the *Century Magazine*, and United States diplomat.

Box 11 Bibliography, indexes, and articles Anderson and Ratzlaff used to compile their bibliography.

Box 12 Articles and reports written or edited by Anderson on Tesla's theories, inventions, and lectures; binder of some primary letters, with 2 possibly written by Tesla, and others concerning him. There are several portfolios containing Anderson's views on public opinions about Tesla and his work.

Box 13 Research materials used in Anderson's writing and scholarship, including photocopies from books, correspondence with other experts and institutions, FOIA requests, and materials from the Tesla Museum in Belgrade, Serbia.

Series III. Topical

Series three contains topical materials relating to Tesla including radio wave development and Tesla's role in wireless experimentation, and international engineers' conference bearing his name, AC/DC current war, Niagara Falls, Tesla coils, government materials concerning Tesla, and the Wardenclyffe Tower.

Subseries A. Radio History

Box 14 Historical developments in radio history including articles related to Tesla's contributions to wireless radio transmission. There are editions of the *Antique Wireless Association* (AWA) review (1980s-1990). There are copies of Tesla's correspondence with Benjamin F. Miessner.

Box 15 Materials concerning the history of radio including Mid-Atlantic Antique Radio Club newsletters (1980s-1990s), proceedings from the Institute of Radio Engineers (1950s-1960s), and articles from early 20th century.

Box 16 Materials concerning the history of radio including historical context for radio and wireless transmission development. This box also includes Tesla Symposia materials, including commemorative and scholarly articles (1956-1990s).

Subseries B. Tesla Symposia

**The Tesla Symposia is an international technical engineers conference, usually held in conjunction with the anniversary of Tesla's birthday.*

Box 16 Box 16 also includes Tesla Symposia materials, including commemorative and scholarly articles (1956-1990s).

Box 17 Symposia materials, proceedings, commemorations 1970s-1990s; Symposia lectures 1990s.

Subseries C. AC/DC Controversy, Niagara Falls

Box 18 Select articles covering and describing the AC/DC controversy involving Tesla, Westinghouse, and Edison, as well as the development of hydroelectric power at Niagara Falls.

Subseries D. Legal Materials

Box 19 Legal materials and court proceedings including several of Tesla's patent battles, as well as other relevant cases, some dealing with Marconi Wireless Telegraph Co.; requests and correspondence of Leland Anderson to various repositories for said information.

Subseries E. Tesla Coils

Box 20 *Tesla's Coil Builders Association* (1982-1998); topographical maps of Colorado Springs and area (1995); general information about Tesla's Colorado Springs experiments.

Box 21 Materials on Tesla coils, including articles, scholarly papers, and bulletins on Tesla Coils (1890-1980s).

Subseries F. Government Materials

Box 22 Government files: FBI files obtained by Arthur B. Keyes through FOIA requests (1943-1949); correspondence of division of Investigation and Research (1940s); Federal Agency records on Nikola Tesla (1934-1981).

Subseries G. Wardenclyffe Tower

Box 23 Journal articles and other materials on Tesla's Wardenclyffe Tower.

Series IV. Biographical Materials on Tesla's Contemporaries

Series four is comprised of secondary contextual material focused on engineers and scientists of Tesla's time, as well as person who have done research on Tesla, or have conducted more recent experimentation based on his theories and work.

Box 24 Photocopies of research, correspondence of, and biographical materials on prominent scientists and engineers, primarily Tesla's contemporaries, including George Scherff, Steinmetz, and Westinghouse (1890s-1990s).

Box 25 **A-H:** Biography files of prominent scientists and engineers including Tesla's contemporaries, as well as figures/persons that have researched and studied Tesla (1900s).

Box 26 **G-R:** Biography files of prominent scientists and engineers including Tesla's contemporaries, as well as figures/persons that have researched and studied Tesla (1900s).

Box 27 Author extracts from works on or about Tesla; photocopied materials extracted from authors works about Tesla or work based on his theories.

Series V. Tesla's patents and inventions

Series five focus on the over 300 patents Tesla received during his life time, comprised of secondary materials on the subject.

Box 28 Photocopied materials removed from published materials specifically on Tesla's inventions and discoveries such as the electric motor turbines, and wireless radio waves. There is one folder of photocopies of Tesla's own notes (1920s) concerning ether and gravity.

Box 29 Articles, scholarly papers, and reflections on Tesla's inventions, including pumps, turbines, and other machinery. Included are patent materials, Leland Anderson's correspondence with other Tesla scholars about patents and inventions (1880s-1980s).

Box 30 Patent and invention materials, some of which is from NARA, as well as more recent research materials and studies based on Tesla's patents.

Series VI. Scholars Files

Series six contains analytical and research based materials produced Professor Warren Rice and Dr. James Corum based on Tesla's work and theories.

Subseries A. Professor Warren Rice

Professor Warren Rice (b.1925-d.2009) was a mechanical engineer at Arizona State University

Box 31 Professor Warren Rice Papers, **A-H**; college papers and dissertations related to Tesla's theories and work.

Box 32 W. Rice Papers, **H-Z**. Box 32 also includes J.R. Johler reports and papers on radio waves produced by the National Bureau of Standards; research, papers, some correspondence of James R. Wait, an electromagnetic scientist and educator.

Subseries B. Dr. James F. Corum

Dr. James F. Corum is a highly distinguished electrical and electronic engineer, and is a member of the Tesla Memorial Society of New York.

Box 33 Dr. James F. Corum papers including technical and scholarly papers on Tesla; as well as 6 cassette tapes of Corum's speeches to the International Tesla Society, Inc.

Box 34 James F. Corum Papers including technical and scholarly articles and analyses of Tesla's work (1930-1990).

Series VII. Journals and Publications

Series seven contains numerous scientific and engineering publications and journals containing articles about Tesla, his work, or subsequent work and research based in his theories. Several publications are produced by Tesla-centered organizations.

Box 35 Foreign Language publications, primarily the *American Srbobran*, the newspaper produced by the Serb National Federation. There is also a serial titled *Tesla*, published in Serbian.

Box 36 **A-E:** Scientific and engineering periodicals containing articles about Tesla, his work, or research based on his theories. Primarily a variety of copies of newspaper articles.

Box 37 **E**: Scientific and engineering periodicals containing articles about Tesla, his work, or research based on his theories, including: *Electrical Engineers* (1888, 1890, and 1910s), *Electrical World* (1889-1899, 1956-1990).

Box 38 **E-M**: Scientific and engineering periodicals containing articles about Tesla, his work, or research based on his theories, including various electrical and electronic journals.

Box 39 **N-P**: Scientific and engineering periodicals containing articles about Tesla, his work, or research based on his theories, including: *Regular Mechanics*, *Popular Science*, copies of *New York Times* editions (1890s-1990s).

Box 40 **Q-S**: Scientific and engineering periodicals containing articles about Tesla, his work, or research based on his theories, including *Practical Electrics* (1921-1925), *Radio Electronics* (1940s-1960s), *Science and Inventions* (1920s-1930s).

Box 41 **S-Y**: Scientific and engineering periodicals containing articles about Tesla, his work, or research based on his theories, including *The Teslian*, *The Tesla Journal*, a 1931 *Time* edition covering Tesla, Westinghouse publications, and the *Scientific American* (1892-1915).

Box 42 Bound copies of *Electrical World* (1891); On May 1892 edition featuring the full text of Tesla's London lecture; *Illustrated Electrical Review* editions (1890s); *Scientific American* (1900s); all containing articles or references to Tesla's works.

Box 43 *American Srbobran* newspapers on Tesla (1911-1945); copy of "Lightning Over Little London," about Tesla's experiments in Colorado Springs and written by Leland Anderson; assorted other serials.

Box 44 Photocopies of newspaper articles, feature magazine articles, concerning Tesla, his work, inventions, discoveries, and theories from 1890s-1910s

Box 45 Contains *Electrical Review* editions from 1890s-1900s; assorted publications with stories on Tesla.

Series VIII. Audio/Visual Materials

Series eight contains the audio and visual materials within the collection, including photographic reproductions of Tesla and his work, VHS tapes containing Tesla features and interviews with Leland Anderson, Tesla correspondence from the LOC on microfilm, and cassette tapes with audio recording of lectures and speeches concerning Tesla and his work.

Box 45 Box 45 also contains several larger photographs of Wardenclyffe tower, machinery, and turbines. There are also 2 images of the rock band Tesla.

Box 46 Photographs of Tesla, machinery, turbines, Wardenclyffe, Tesla with friends and associates, Tesla scientific experiments, electromagnetic experiments Leland Anderson was involved with. The photographs concerning Tesla are primarily reproductions or copies.

Box 47 VHS Tapes (1990s): National Tesla Productions, Inc., feature programs on Tesla and his works. Three Tapes contain a personal interview with Leland Anderson about his interest in Tesla and a history of Tesla's work.

Box 48 Microfilm (1888-1940s): Tesla correspondence on microfilm from Library of Congress, Tesla Museum, and Columbia University Library.

Box 49 Cassette Tapes: Scholars and scientists lectures, radio tributes to Tesla, 1990 lectures from Tesla Symposia. There are also a number of 35mm slides, containing images of Tesla materials and ephemera Leland Anderson photographed.

Arrangement

The Leland Anderson Collection on Nikola Tesla consists of 49 boxes and has been arranged into the following 8 series:

Boxes 1-7: Series I. Contextual / Biographical about Tesla
Boxes 8-13: Series II. Leland Anderson's Research
Boxes 14-23: Series III. Topical
 Boxes 14-16: Subseries A. Radio History
 Boxes 16-17: Subseries B. Tesla Symposia
 Box 18: Subseries C. AC/DC Controversy, Niagara Falls
 Box 19: Subseries D. Legal Materials
 Boxes 20-12: Subseries E. Tesla Coils
 Box 22: Subseries F. Government Materials
 Box 23: Subseries G. Wardenclyffe Tower
Boxes 24-27: Series IV. Biographical Materials on Tesla's Contemporaries
Boxes 28-30: Series V. Tesla's Patents and Inventions
Boxes 31-34: Series VI. Scholars Files
 Boxes 31-32: Subseries A. Professor Warren Rice
 Boxes 33-34: Subseries B. Dr. Jeff F. Corum
Boxes 35-45: Series VII. Journals and Publications
Boxes 45-49: Series VIII. Audio / Visual materials

Statement of Acquisition:

Gift from Leland Anderson and the Serb National Federation in 2004.
Archives accession # 2004.0160

Restrictions:

None.

Preferred Citation:

Leland Anderson Collection on Nikola Tesla, 1880s-1990s, MSS 0481, Thomas and Katherine Detre Library and Archives, Senator John Heinz History Center

Related Material:

Westinghouse Electric Corporation Records, 1865-2000, MSS 424, Thomas and Katherine Detre Library and Archives, Senator John Heinz History Center

Separated Material:

A large amount of biographical and technical books on or about Nikola Tesla and his work were separated from the collection and added to the Library's holdings:

- Cheney, Margaret, Tesla: Man out of Time, Dell Publishing Company, New York NY, 1981. [paperback]
- Beckhard, Arthur J, Electrical Genius Nicola Tesla, Julian Messner, Inc, New York, 1959.
- Cheney, Margaret, Tesla: Man out of Time, Prentice-Hall, Englewood Cliffs, NJ, 1981.
- Hnkoja Tecja, 1994

- Dommermuth-Costa, Carol, Nikola Tesla: A Spark of Genius, Lerner Publications Company, Minneapolis, MN, 1994.
- O'neill, John J, Prodigal Genius: The Life of Nikola Tesla, Ives Washburn, Inc. (New York, NY: 1944)
- Hunt, Inez and Wanetta W. Draper, Lightning in His Hand the Life Story of Nikola Tesla, Denver: Sage Books, 1964.
- Seifer, Marc J, Wizard: The Life and Times of Nikola Tesla, Biography of a Genius, Secaucus, NJ: Birch Lane Press, 1996.
- Richardson, Thomas Lee (researcher), Introducing Nikola Tesla through some of his achievements, Vancouver, BC: Gastown Production, nd.
- Wise, Tad, Tesla: A Biographical Novel of the World's Greatest Inventor, Atlanta: Turner Publishing, Inc, 1994.
- Walters, Helen B, Nikola Tesla: Giant of Electricity, New York: Thomas Y. Crowell Company, 1961.
- Transmission of Power. Polyphase System. Tesla Patents, Pittsburgh: Westinghouse Electric and Manufacturing Company, nd(1893?).
- Handbook of Westinghouse Watthour Meters, Newark, NJ: Westinghouse Electric & Manufacturing Company, nd.
- Tesla, Nikola, My Inventions, the Autobiography of Nikola Tesla, Williston, VT: Hart Brothers, 1982.
- Martin, Thomas Commerford, The Inventions, Researches and Writings of Nikola Tesla, New York: The Electrical Engineer, 1894.
- Pond, Dale & Walkter Baumgartner, Nikola Tesla's Earthquake Machine, Santa Fe, NM: The Message Company, 1995.
- Glenn, Jim editor, The Complete Patents of Nikola Tesla, New York: Barnes and Noble Books, 1994.
- Hayes, Jeffery A (compiled by) Tesla's Engine: A New Dimension for Power , Milwaukee: Tesla Engine Builders Association, 1994.
- Hayes, Jeffery A (compiled by) Boundary-Layer Breakthrough: The Bladeless Tesla Turbine (developed by C.R. "Jake" Possell), Colorado: High Energy Enterprises, Inc. 1990.
- Tesla, Nikola, Experiments with Alternate Currents of High potential and High Frequency, a lecture, New York: Mcgraw Publishing Company, 1904.
- Tesla, Nikola, Experiments with Alternate Currents of High potential and High Frequency, a lecture, New York: W.J. Johnston Company, Ltd, 1892.
- Tribute to Nikola Tesla presented in Articles * Letters * Documents, Beograd: Nikola Tesla Museum, 1961.
- Nikola Tesla Lectures * Patents * Articles, Beograd: Nikola Tesla Museum, 1956.
- Thomson vs. Tesla, In the United States Patent Office, 1895.
- *Proceedings: Tesla Symposium*, New York City, January 30, 1976.
- *Nikola Tesla: Correspondence with Relatives*, Belgrade: The Tesla Memorial Society, Inc, 1995.
- Stillwell, L.B, Transmission of Power, Pittsburgh, PA: Westinghouse Electric and Manufacturing Company, 1893. (exists in library collection)

- Tesla, Nikola, Nikola Tesla: Colorado Springs Notes 1899-1900, Belgrade, Yugoslavia: NOLIT, 1978.
- O'neill, John J, Prodigal Genius: The Life of Nikola Tesla, New York, NY: David McKay Company, Inc, 1944.
- Cheney, Margaret, Tesla: Man out of Time, New York, NY: Prentice Hall, 1981. (2 copies, hard-cover)
- Martin, Tomas Commerford, The Inventions, Researches and Writings of Nikola Tesla, New York, NY: Barnes & Noble Books, 1992.
- Tesla Patents, Transmission of Power: Polyphase System, Pittsburgh, PA: Westinghouse Electric and Manufacturing Company, 1893.
- Martin, Thomas Commerford, The Inventions Researches and Writings of Nikola Tesla, Milwaukee, WI: Lee Engineering Company, 1952.
- Johnston, Ben editor, My Inventions: The autobiography of Nikola Tesla, Austin, TX: Hart Brothers, 1982.
- Ratzlaff, John (editor), Tesla Said, Chula Vista, CA: Tesla Book Company.
- Ratzlaff, John (editor), Tesla Said: Reference Articles for Solutions to Tesla's Secrets, Millbrae, CA: Tesla Book Company, 1981.

Processor:

Preliminary processing by Alex J. Toner on 12/19/12. An inventory was created by Jennifer Bator in 2008.

Title: Leland Anderson Collection on Nikola Tesla
Dates: 1880s-1990s
Creator: Anderson, Leland
Catalog Number: MSS 0481

Thomas and Katherine Detre Library and Archives
Senator John Heinz History Center
1212 Smallman St.
Pittsburgh, PA 15222

Extent: 49.5 linear ft. (49 boxes)
Language of Materials: English, Serbian

Sponsorship:
This collection has been made accessible as part of an NHPRC-funded Basic Processing grant.

Abstract
Leland Anderson is a writer and researcher who is the author a number of published works on the electrical engineer and inventor Nikola Tesla. Tesla, who worked for the Westinghouse Electric and Manufacturing Company in 1888, was known for his work on the alternating current system, radio communication, and X-ray technology. Beginning in the 1940s and continuing over the next 50 years, Anderson compiled a large collection of research materials documenting the life and work of Tesla. The Leland Anderson Collection on Nikola Tesla primarily contains secondary research material, including journals, articles and other publications, and photocopies archival material from various research institutions.
Also included are Anderson's published works, biographical material on Tesla's contemporaries, and audiovisual material related to Tesla.

Historical/Biographical Note

Leland Anderson

Leland I. Anderson (b. 1928) is a writer and researcher who is the author of a number of published works on the electrical engineer and inventor Nikola Tesla. Anderson, an electrical engineer, technical writer, and former manager of the Minnesota State Historical Society, took up an interest in Tesla during high school in the 1940s, shortly after Tesla's death. Over the course of the next 50 years, Anderson compiled a large collection of materials documenting Tesla's life, work, inventions, technical theories, and more recent work based Tesla's ideas. Anderson founded the Tesla Society, and was editor of its newsletter, *Tesliana*, beginning in the 1950s. In 1956, he and John T. Ratzlaff published an extensive bibliography of over 3,000 citations of writings by or about Tesla, which was subsequently updated over the following decades. Additionally, Anderson has written and edited numerous books on Tesla and his work.

Nikola Tesla

Nikola Tesla was an electrical engineer and inventor who experimented in electricity, magnetism, and radio waves and is best known for developing the alternating current (AC)

electrical supply system and the polyphase induction motor Recognized today as a Serbian-American, Tesla was born in 1856 in Smiljan, Lika, which today is in modern-day Croatia. After completing his education in Prague in 1880, he worked as chief electrician for a telephone company in Budapest, and soon after was employed for the Continental Edison Company in Paris.

Tesla accepted a position working with Thomas Edison in America in 1884, although he resigned after only a year following a payment dispute with Edison. With the backing of several investors the short-lived Tesla Electric Light and Manufacturing Company was formed in 1885, followed by the Tesla Electric Company in the spring of 1887. In 1888, after hearing of a public presentation Tesla made proposing his alternate-current motor and transformers, George Westinghouse licensed the patents for Tesla's polyphase induction motor, and several of his transformers designs. Tesla was subsequently hired on a year-long contract to continue his AC designs and act as a consultant for Westinghouse Electric and Manufacturing Company's labs in Pittsburgh, Pa. During the year Tesla lived and worked in Pittsburgh, he furthered his AC designs, actually using the system to power some of the city's streetcars for a short time. Nikola Tesla became a naturalized American citizen in 1891.

Tesla assisted Westinghouse in powering the 1893 Columbian Exposition in Chicago, demonstrating to the public the viability of large-scale alternating current power. He experimented with X-ray technology and wireless radio development, and participated in several industrial and scientific organizations including serving as vice president of the American Institute of Electrical Engineers between 1892 and 1894. In 1899, Tesla began a year-long series of high-voltage electricity experiments in Colorado Springs, Co. Soon after his Colorado experiments, which gained national publicity, he received funding to build a large transmission tower on Long Island, New York. Wardenclyffe Tower, which was never completed, was intended by Tesla to conduct wireless communication and wireless electrical transmission tests.

Tesla's research and experimental interests late in his life revolved around aviation, interstellar power sources, extraterrestrial communication, weaponized energy, electrotherapeutics, and radio-controlled. While he became more reclusive has he aged, Tesla earned roughly 300 patents internationally during his lifetime, including several bearing his name, such as the Tesla coil and Tesla turbine. Nikola Tesla died in the New Yorker hotel, where he had long since taken up resident, in 1943.

Scope and Content Note

The Leland Anderson Collection on Nikola Tesla documents the life and work of engineer and inventor Nikola Tesla. The collection primarily contains secondary research materials compiled by Anderson over the course of 50 years, and includes photocopied contextual materials on Tesla's life and times from research institutions; Anderson's own work; topical materials covering Tesla's various fields of work and experimentation; biographical material on Tesla's contemporaries; journal and scholarly articles on Tesla's inventions and patents; journals, newspapers, and publications on Tesla and his work; and audio/visual materials including


TESLA ELECTRIC EXPERIMENTERS
3 AMY LANE
QUEENSBURY, NY 12804
HAPPY BIRTHDAY 39 USA
HAPPY BIRTHDAY 39 USA
HAPPY BIRTHDAY 39 USA
USA 1c Tiffany Lamp
USA 1c Tiffany Lamp
3c USA
MR. JEFF BEHARY
627 36TH STREET
WEST PALM BEACH
FL 33407
33407+4303

MASK OF FU MANCHU

this article contains information That could only be known by having access To the book prior to publication. It may be mcfarland's idea for pre-publicity. Enjoy. IZY

the spark of the covenant

your mother was the lightening!

He was known as "Mr. Electric" around the back lots of nearly every major Hollywood studio for over fifty years. With creative bursts of alternating currents that emanated from the machines he made, this visionary electrical engineer forever forged in our minds that image of an eternal life-giving force harnessed from the heavens beginning with FRANKENSTEIN (1931). His machines—if put in the hands of extraordinary evil despots—could easily destroy mankind as in THE MASK OF FU MANCHU (1932).

His innovative equipment would not only serve to modernize the look of Gothic horror and science fiction forever, but also tap into the latent fears society had in understanding the ramifications of this new power. This special effects genius created the instruments that served the "mad" scientists of over 100 motion pictures, serials and television programs combined. His gadgets can be seen in motion pictures from the silent era to the Golden age and beyond. A science teacher with an amazing sense of humor, he remained busy until his death in 1984 at the age of 87. His creations set a standard in Hollywood special effects and his influence is still felt in films today.

watt went before

Born in Montana in 1896, Kenneth Joseph Strickfaden even as a young child had a mindset for science, technology and adventure. While in his teens, his parents divorced and Ken and his dad relocated to Santa Monica, California, making the drive in a model-T Ford. In high school Ken showed a deep passion for chemistry and physics and in his spare time he would tinker with electrical devices. Fascinated with how electrical technology was transforming the way people lived, nobody in his life could have influenced Ken more than Nikola Tesla—inventor of the AC (alternating current) induction motor, x-rays, vacuum tube amplifier, wireless radio and, of course, the Tesla Coil.

As a young man, Ken worked for a time in various amusement parks across the nation that utilized the new electric motors that powered many of the attractions. It was there that he learned electrical mechanics and was further able to develop his skills (including photography) when he entered the Marine Corps in 1918 during the First World War. After the war, he was urged to persue his talents by fellow electrical enthusiast Hugo Gernsback (well-known publisher and inventor of the time) and Ken entered an amatuer electrical experiment contest. Anticipating what would be his future Ken won first prize and a photo of him standing next to his electrical gizmos appeared in the November, 1919 issue of the "Electrical Experimenter" magazine.

After this small victory, Ken heeded to the calling "go west, young man" and once again in a Ford jalopy, he traveled cross-country (when it literally took weeks to make the trek), often sleeping wherever he could find space (haystacks, open fields and even in the car). Ken loved to enhance his education with hands on experience. He not only worked as an aeronautical mechanic, but in his own time he constructed various electrical instruments in his garage that were based on the designs of Tesla, often using whatever spare parts were lying around. Airplane, bicycle, and scrap industrial parts all found their way into his creations and eventually onto the silver screen. Often he would lovingly personify his "electrical children" with very funny and pretentious names.

MR. SHOCK THEATRE

the spark of the covenant

your mother was the lightening!

He was known as "Mr. Electric" around the back lots of nearly every major Hollywood studio for over fifty years. With creative bursts of alternating currents that emanated from the machines he made, this visionary electrical engineer forever forged in our minds that image of an eternal life-giving force harnessed from the heavens beginning with FRANKENSTEIN (1931). His machines—if put in the hands of extraordinary evil despots—could easily destroy mankind as in THE MASK OF FU MANCHU (1932).

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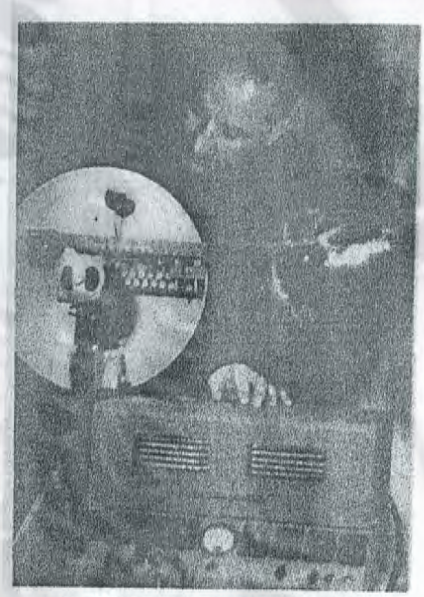
KENNETH STRICKFADEN

KENSTRIC SCIENCE SHOW

828-1256 ~~EX 52435~~ 853 26th ST. SANTA MONICA CALIF.



IMAGINEERED INTERPRETAINMENT



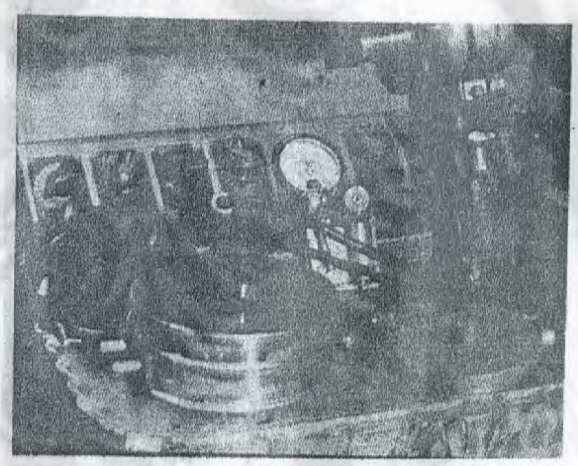
MUSIC OF THE SPHERES



MAGIC MELODYNE MUSIC
JUST-INTONED PHOTO-CELL ORGAN



HARMONEYE



MAGNETROCIOUS MAGNIFICATION

ELECTRICITY

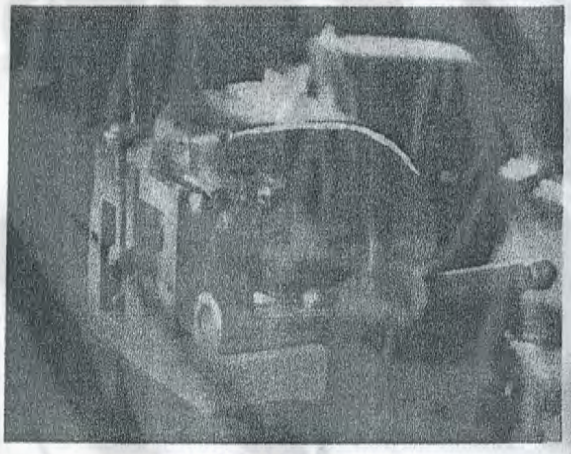
LIGHT

COLOR

SOUND

MUSIC

GYROSCOPES



EDUCATED NOISES

Front panel from a 1960s brochure for Ken Strickfaden's science show in Santa Monica, California.



Dr. Mannering (Patric Knowles) reactivates the Frankenstein factory to end the curse of the Wolf Man (Lon Chaney Jr.). At right is the undying monster (Eddie Parker doubling for Bela Lugosi) in FRANKENSTEIN MEETS THE WOLF MAN (Universal, 1943).

In 1921 Ken married Gladys Ward and together they had two daughters, Carol and Marilyn. After working many years trying to support his family with dead-end jobs, the young pioneer started maintaining the electrical equipment owned by the flourishing movie industry in Hollywood. One of the first films that Ken worked on was WINGS (1927)—a silent war epic that won the very first Oscar for "Best Picture."

RETURN OF SHERLOCK HOLMES (1929) was the first motion picture to incorporate one of his creations, and Ken's machines were showcased to great effect in 1930's JUST IMAGINE.

"here in these machines..."

What one must understand from a historical perspective is that popular culture is greatly affected by the technologies of its day. In the late 1920s, the industrial-age aesthetic had permeated everything: art, design, architecture, advertising and film. Some movements were positive in their approach as with Art Deco and Art Moderne, while others were more fearful as to what the machine age coupled with modern science would bring society, as with German Expressionism and The Dada movements in Europe. It was this new machine age visual that probably influenced James Whale and his associates in the production of FRANKENSTEIN, more so than Shelley's novel.

Ken Strickfaden was in the right place at the right time to see his inventions incorporated into the Universal production. His good fortune was predicated upon that old theorem of opportunity and preparedness equals success.

"I learned a great deal from you at the university," Henry Frankenstein tells Dr. Waldman. "...about the violet ray...the ultraviolet ray!—which you said was the highest color in the spectrum. You were wrong. Here in these machines I have gone beyond that. I have discovered the great ray that first brought life into the world." Perhaps those memorable lines are more prophetic than we realize.

"Electricity is life," Strickfaden once told an interviewer. "We are just a bunch of sparks with various quantities of air." Certainly medical science has confirmed that. High voltage shocks are used to resuscitate a stopped heart and anyone who has ever recoiled in pain after having walked across a statically-charged carpet and become a human "lightning rod" knows we all have a potent electrical network integrated into our systems.

nature's fury

When asked about his contributions to Universal Pictures, he said dismissively, "The styling all depended on what junk I had on hand!"

The electrical apparatus Strickfaden employed was exceedingly dangerous to say the least. Jacob's ladder, gyros, fire rings, rotary spark gaps and Tesla's coil were devices that generated tremendous voltage quite capable of killing someone. No wonder that during production of FRANKENSTEIN, Boris Karloff developed both a tremendous fear and respect for the apparatus which sparked and flashed around him as he lay half-naked on the laboratory table.

Vividly recalling the spark burns he sustained from stray embers, Boris actually refused to be involved in any way, shape or form with one of Ken's machines during filming of THE



Mirror image—First Frankenstein Karloff (here playing Dr. Gustav Neinmann) comes face to face with his past in the person of Glenn Strange (the final Universal Frankenstein) in HOUSE OF FRANKENSTEIN. (Universal, 1944.)

MASK OF FU MANCHU. The scene called for a generated quarter-million volt lightning bolt to dance over his fingertips. The crew assured Boris that no harm would come to him for they had rigged a wire that would travel from his hand, up his arm, down his leg and then ground out to the floor. Boris refused to the point of shutting down production for the day.

It was decided that in order to keep production moving, Ken would have to act as Karloff's stand in. It is actually a heroic Ken playing Fu Manchu in the scenes with his equipment! But because of a faulty ground, Ken nearly was electrocuted during the filming. According to accounts from members of the crew, the shock actually blew him off his feet, sent him flying through the air to finally land on his back. At first the crew thought he was killed, but fortunately he was only stunned and winded, and they were able to resuscitate him.

But even with such unfortuante mishaps, Strickfaden had found his niche and started to group his machines together realizing he could free-lance renting his equipment out to the different studios that needed his special services. His next films, CHANDU THE MAGICIAN for Fox (1932) and Universals' BRIDE OF FRANKENSTEIN (1935) further cemented his unique style.

high-charged diffhangers

The motion picture serial enjoyed much success before the advent of television. "To be continued," at the end of a film not only meant more fantasy fun for moviegoers but also guaranteed consistent box-office for the motion picture industry. By this time Strickfaden's equipment was in high demand and over the next decade it appeared in a variety of now-classic serials among them FLASH GORDON, BUCK ROGERS THE SHADOW, THE LOST CITY, THE CLUTCHING HAND, THE PHANTOM EMPIRE, THE MYSTERIOUS DR. SATAN and THE UNDERSEA KINGDOM. All of these serials dealt extensively with high-tech conflicts between good and evil embodied by the machines and matched with the personalities of the men that controlled them.

ken-etic energy

It was around this time in the early 1930's that Ken took all of his equipment and created the "Kenstric" Science Show. Basically a "science demonstration" starring the machines he created, his show explored electrical fundamentals and principles. Ken toured with his show across the United States and Canada and is reported to have lectured over 1,000 times. A born risk taker, Ken had succeeded in establishing a second career with his tours. He was determined to be a positive force in educating people about the benefits of science. Ken believed in an altruistic approach to understanding technology—that just because we lived in a capitalist society didn't mean that the advancements made had to be motivated out of greed and power. That belief helped keep his services in demand even

when his gadgets were not the obvious stars of a scene as his major projects at the end of the 1930s attest.

Strickfaden machines were again at the forefront in 1939's SON OF FRANKENSTEIN but he also contributed that same year to MGM's THE WIZARD OF OZ and Disney's FANTASIA the following year. While his work is well known on Universal's third Frankenstein film, the other two films utilized his unique special effects talents to enhance the productions.

In 1953 Ken was involved in Paramount's sci-fi masterpiece, WAR OF THE WORLDS. With the world now well into the atomic age and space travel was no longer considered "that crazy Buck Rogers stuff." Thus the film version directed by legendary puppet-animation maestro George Pal modernized the 1898 story by HG Wells and brought the invading Martians into America's postwar consciousness. Specifically what Strickfaden's actual contributions were in this film are not well known, however it is a distinct possibility that those death-ray sparks emanating from the Martian war machines have Ken's hand in them.

electriaty in the air!

Although Television itself had been around since the early 20th century, it wasn't until the 1950's that commercial television became a major media force. Both radio and the motion picture industry reeled in the wake of its emerging power. Although the major film studios felt a loss of revenue, Strickfaden, as an free agent, prospered as his services were now needed by the young and strong television networks well into the next decade. Pick any sitcom, commercial, space show, variety show or creature feature of the era and chances are pretty good that Ken's mad scientist equipment is seen on screen at onetime or another. "Captain Video", "Space Patrol", "Tom Corbett—Space Cadet" and "The Munsters", to name a few, all used Strickfaden's magic.

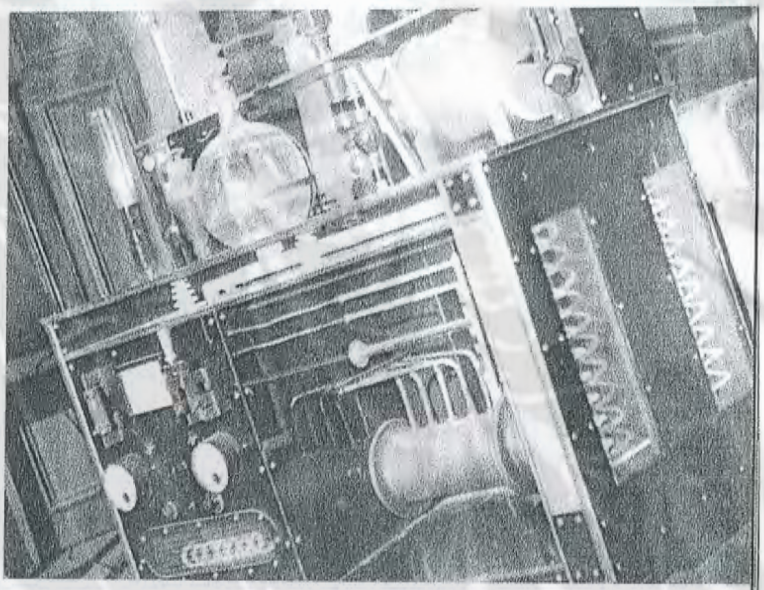
a career recharged

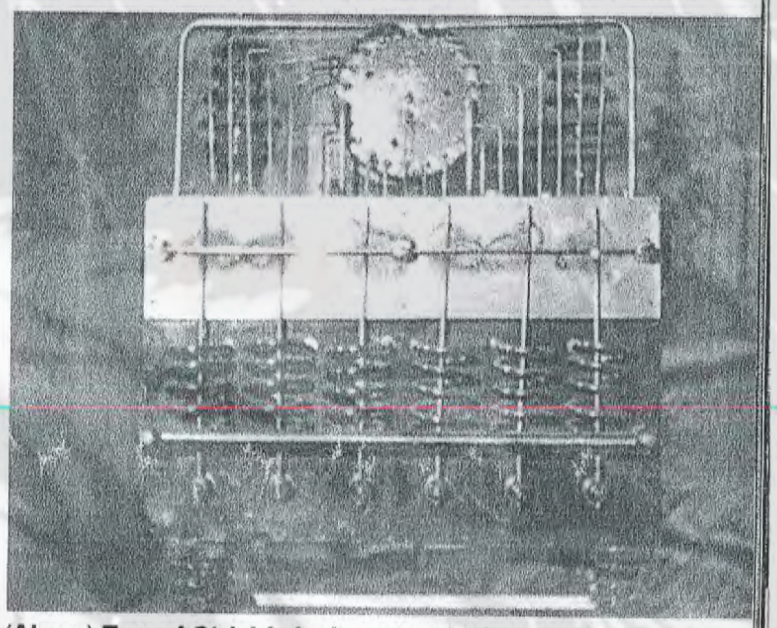
By the end of the 1960s it was becoming apparent that Strickfaden's devices were becoming outdated. With fast-developing computer technology the world of creative "real-time" special effects were being retired in favor of "better, faster, cheaper" digital technologies.

Then, in 1971, shlockmeister Al Adamson rented much of the electrical lab equipment originally used in FRANKENSTEIN for his next film. Strickfaden was more than willing to supply his machines so for a song, he dusted of his equipment for use in the new film. Stirckfaden's contributions are inarguably the highlight of the otherwise dismal DRACULA VS. FRANKENSTEIN.

In 1973 Strickfaden's equipment hummed and crackled in the exploitation film, BLACKENSTEIN. Young moviegoers might never have truly appreciated the genius and power of Ken's machines but fortunately Hollywood has its fair share of personalities that not only recall but cherish the genius of the Ghoulden age. Thus Strickfaden was given a chance to shine again in Mel Brooks' monsterpiece, YOUNG FRANKENSTEIN (1974).

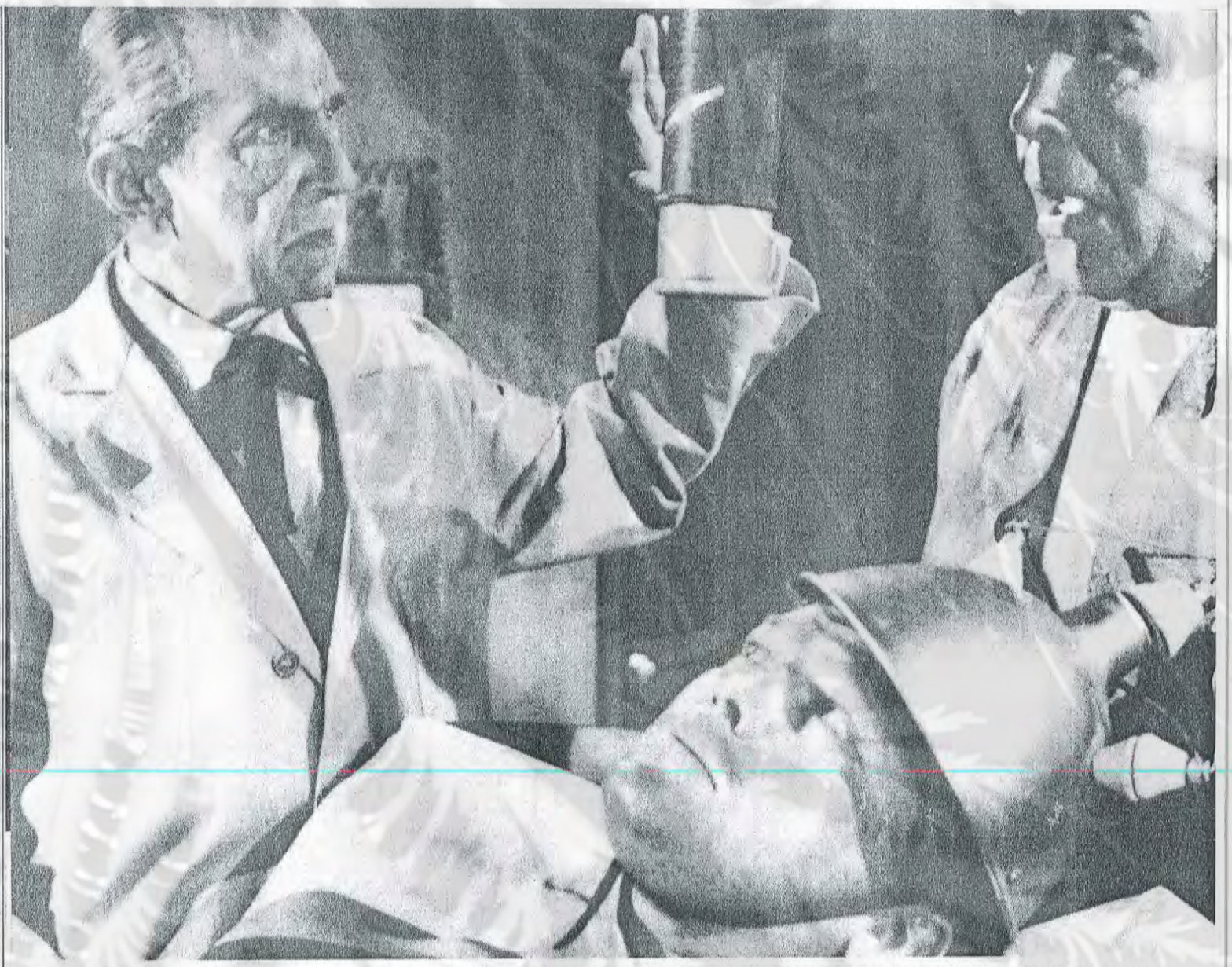
By the 1980s, computer technology—particularly advanced by George Lucas' STAR WARS—had become the





(Above) Two of Strickfaden's more widely used devices. (Below) Shooting on the set of THE WIZARD OF OZ (MGM, 1939.) Note the heavily blimped camera on the crane in the center of the foto.





"I'll thank you to refer to it as a 'Transmutation Atomic Growth Mechanism' and not a 'flood light reflector' and no—you can't have it right now. You'll just have to watch 'Tom Terrific' without it!" Poor Bela may not have had benefit of super Strickfaden devices in his later years but we can't think of anyone who could have worked with an Ed Wood budget and still managed to stay so deftly in character! (Bela Lugosi (Dr. Vornoff), Jack Warren (Jake), Tor Johnson (Lobo) BRIDE OF THE MONSTER, Filmakers Releasing Org., 1956)

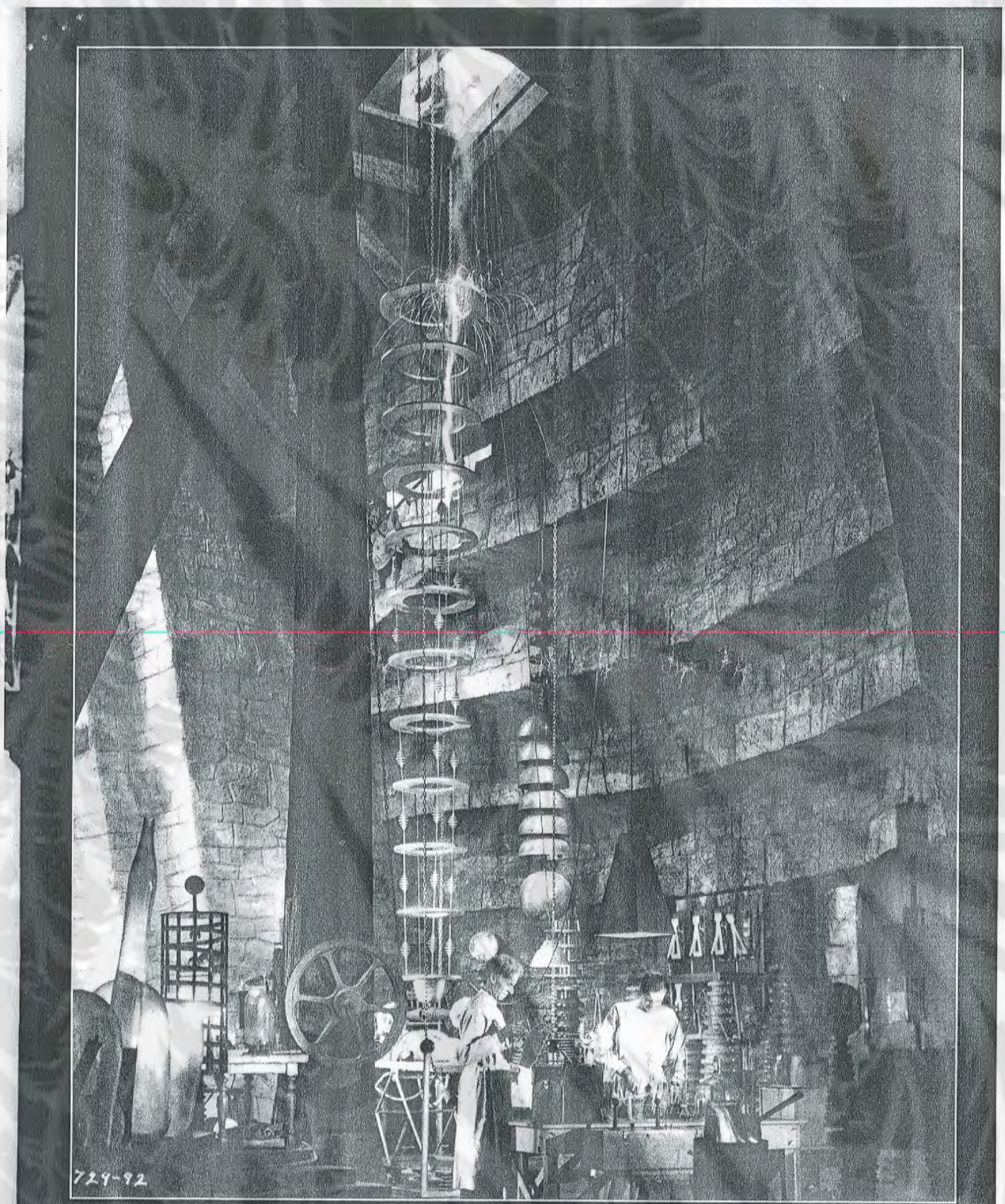
standard for special effects. Strickfaden—now in his eighties—had a unique appreciation of what harnessed electricity could do and was very excited about this new technology. In 1981, The Academy of Motion Picture Arts and Sciences sponsored an event in Ken's honor that blended his film career with his science show in "The Magic Machines of Ken Strickfaden." Much to his delight, hundreds of horror and science fiction fans turned up for the show and Ken received a deafening ovation.

Ken passed away just shy of his 88th birthday. What is immeasurably interesting about Strickfaden's life is obvious; it is his work in film and his loving passion for humanity and science yet not much has been written on the man. Harry Goldman, an electrical engineer and longtime friend of Strickfaden, has assembled a much-anticipated biography titled "Dr. Frankenstein's Electrician" (McFarland Publishing). This book promises to contain a lot of insight on the man, rare personal unpublished photos and reveals the fate of his equipment.

a cinematic ben franklin

As with any pioneer, Ken laid the groundwork that shaped electrical special effects in the cinema. His basic designs of his machines have not changed since he first created them. Strickfaden had the wherewithal to transform his creativity into complex yet tangible objects and his contributions to horror and science fiction cinema remain invaluable. A classic is measured by its ability to stand up over time and it is undeniable that Ken Strickfaden added the "sparks" that continue to sustain the life of the classics. In the end, Strickfaden was very right: "Electricity IS life!"

This is the first in a special series we will be bringing you on the technical aspects of Ghoulden age movie making with an emphasis on "how they did it." You'll be amazed at how the "pioneers" of cinema created the world's most legendary films with no road map, no computers, little money and no idea of how they were going to make the impossible a screen reality!—RF



Strickfaden's high water mark—the impressive lab where Dr. Pretorius (Ernest Thesiger) and Henry (Colin Clive) performed the unholy experiment. Note the figure of Ludwig (Ted Billings) standing in the aperture by the top of the towering "cosmic diffuser" which reaches up several stories above the sound stage floor. (BRIDE OF FRANKENSTEIN, Universal, 1935.)

messages included an exchange of greetings between the Governor General of Canada and the President of Ireland. More details are be posted at http://www.cbwireless.ednet.ns.ca.

HENRY M. BRADFORD
Chair, Cape Breton Wireless Heritage Society
via e-mail

COMMENTS ON *THUNDERSTRUCK* REVIEW

As Bill Fizette's review [July] suggests, members who read Erik Larson's *Thunderstruck* might appreciate its interwoven detail on Marconi's Signal Hill, South Wellfleet, and Glace Bay stations. But controversial points can give pause.

One is a distorted time frame: Larson's "making it seem," as a *New York Times* reviewer said, "as if he's writing about concurrent events when they're separated by seven or eight years." Another is an unsubstantiated conclusion: that the Crippen case "did more to accelerate the acceptance of wireless as a practical tool than anything the Marconi company previously had attempted." Crippen's wireless-assisted capture occurred in 1910. By then, Marconi's wireless—patented in 1897—already had made headlines internationally for facilitating dramatic sea rescues, revolutionizing weather and shipping reports, triggering an amateur wireless boom, slashing transatlantic message costs, and resulting in Marconi's receipt of the Nobel Prize in 1909.

ALFRED BALK, Author of *The Rise of Radio, from Marconi through the Golden Age*, McFarland, 2006
Huntley, IL

QUALITONE SPEAKER IDENTIFIED

I was very happy to see the article *The Qualitone Horn Speaker* in last July's "Radio Reproducers" column. I have had one of these speakers for several years and am enclosing a picture. Now I know that it is a Qualitone Model 1R (single earphone version). Mine has both "tone chambers" intact but the cone is not in as good condition as the Model 1 (double earphone version) pictured in the article. My 1R has no nameplate or decal of any kind on it and no sign that there ever had been one.



Alan McChesney's Qualitone Model 1R.

The article mentions that there is green felt on the bottom of the base. The felt is not present on mine, nor are there any traces of it. On the rear of my speaker there is a rubber grommet for the headphone to seal against. I don't see grommets on the Model 1 pictured in the article, but it looks like one is shown in the drawing at the lower left of the original ad. Perhaps these features varied with the production runs.

Thanks very much for shedding some light on this old horn for me. I have enjoyed collecting antique radios and speakers for nearly 40 years, and it is especially pleasing to put a name on an unknown.

ALAN MCCHESNEY, N2ZHS
Scotia, NY

HAM EVENT SCHEDULE?

I enjoy the *Journal* very much and would like to make a suggestion. Would you add a small section occasionally giving brief consolidation of all the different AWA ham "contests," QSO parties, etc. for the coming six months or so? I would like to participate in these more frequently but fail to notice or record some of the announcements, or occasionally do not read the *Journal* until after an event.

CARL E. WOLFE, W2IQK
Baker, NY

This would certainly be a useful enhancement to our ham event announcements and one that could help increase participation. We'll look into it!

JOHN ASHTON'S FASCINATING MEMORIES

Larry Babcock's excellent article, "Air/Ground Communications in World War I," (April, 2008) brought to mind a letter of communication received many years ago from John Oliver Ashton. Mr. Ashton worked as an engineer on J.P. Morgan's palatial steam yacht "Corsair" and later as test engineer on Senator Nelson W. Aldrich's yacht "Alvina." Ashton's father was a financial officer for Okonite Wire and Cable and signed the checks to support such pioneers as Marconi, Tesla, Edison, Fessenden, deForest, and so on. Ashton revealed that "Tesla was 'Nick' to us," and went on to tell of a close association with schoolmate Edwin H. Armstrong with whom he worked during the latter's experiments with feedback circuits and early radio patents.

Also of interest was Ashton's work in early wireless with Earle Ovington, the first airmail pilot. "I palled with men like Earle Ovington on whose Bleriot monoplane I installed my own original system, using the first counterpoise antenna, in 1910. And while Earle soared at some 1500 feet over Mineola/Hempstead we carried on the first two-way radio (communications) from plane to ground…

…My first wireless transmitter of any size was a 10 kW open core transformer and to that I added an open gap and a huge glass plate condenser. With my huge antennas over Yonkers I could get the distance that [other boys envied, allowing me to work] ships in the mid-Atlantic. Prior to 1912, no license was required. The air was 'free' and we pioneers did have fun that no one these days can quite understand or imagine."

Ashton went on to describe his participation in the Madison Square Garden electrical exhibitions with friend Earle Ovington. "He was a millionaire's son and close friend of Tesla. Earle would put on spectacular displays of fireworks using a huge Tesla coil mounted on a platform over the crowd…and would let me venture forth on the glass platform [to] take big sparks of terrifying length off a wand that I held in my hand and which, in turn, jumped to the ball on top of the Tesla coil. Tesla would stand by with a paternal eye on us both and smile, as he was somewhat of a showman himself…"

HARRY GOLDMAN
Tesla Electrical Experimenters
Queensbury, NY

WANTED:

MORE MEMBER ARTICLES!

One of the main missions of *The AWA Journal* is to provide a venue where members can share their historical discoveries and insights, collecting triumphs, restoration chronicles and almost anything else of interest to others who participate in our fascinating hobby. So let us hear from you!

We want to make it as easy as possible for your work to be published in the *Journal*, so don't hesitate to send queries or completed articles in any form. There are no special format or structure requirements. It's fine just to write in conversational style as if you were speaking with a friend.

The typical article size is 1,500-3,000 words, but wide variations are possible. You can send hard copy by snail mail or attach digital files to an e-mail (use any standard word processing format or send a plain text file).

Digital photos sent by e-mail are fine. Most modern digital cameras provide more than enough resolution for our needs. Files (or paper prints) in color can be converted to black-and-white here. Just don't embed pictures in your word processing document, unless you also send them as separate files.

Why not plan to sit down and write us soon! Contact Marc Ellis at P.O. Box 1306, Evanston, IL 60204-1306.

About Our Authors

RICHARD T. AMMON
Superheterodyne-Plus-TRF Receivers

Richard Ammon has served as a U.S. Army Signal Corps Instructor of basic and advanced electronics. He has also had a career of almost 25 years in broadcasting, holding positions from DJ to Sales Manager, and has supervised ground-up construction of a 50 kW FM station, complete with new studios. He has taught Radio/TV Broadcasting at Wabash Valley College in Mt. Carmel, IL. Most recently, he spent 20 years in the computer industry in varied positions that included sales and web site design. He currently works for the Cheyenne, Wyoming Tourism and Visitor's Center.

Richard has been collecting old radios since he was 12 years old, and still has the first two radios he bought (how about an AK 944 and a Philco 70 for six dollars?) His collection emphasizes 1927 and earlier sets, and he has been databasing superhets for 8 years—so far documenting over seven hundred brands, models, and variations from 1918 to 1930. This data is on the process of being compiled into an illustrated reference book.

He has served as Editor of the Colorado Radio Collectors' Club newsletter and Publisher of the bi-monthly *Transistor Radio Collector* magazine. Richard is now looking for opportunities to get back into broadcasting and talk radio.

Electrical Oscillators

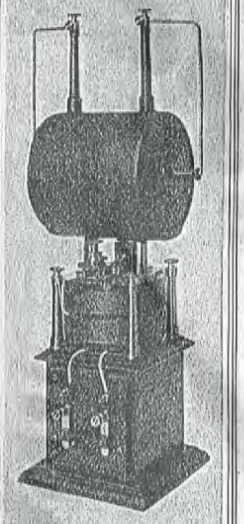


Fig. 1. Oscillator with detachable transformer for experimental purposes

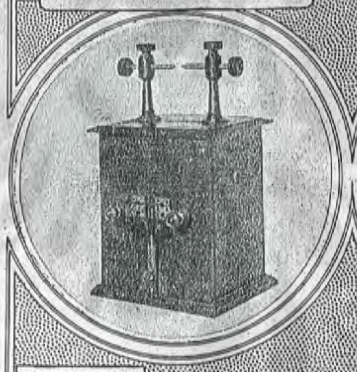


Fig. 2. Small Tesla Coil for gas engine ignition and similar uses

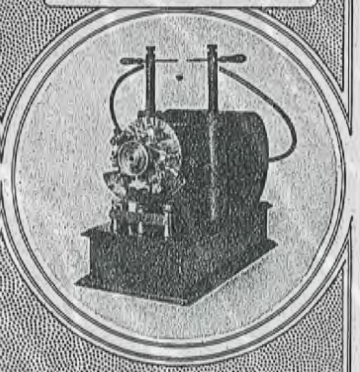


Fig. 3. Tesla Transformer, 12 inch spark, chiefly for wireless

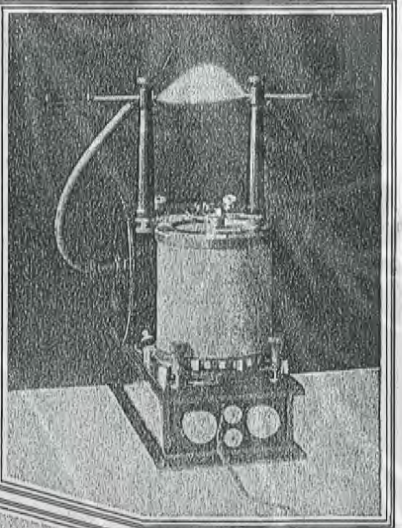


Fig. 4. Tesla Oscillator in action, generating undamped waves



Fig. 5. Later type of Tesla Transformer

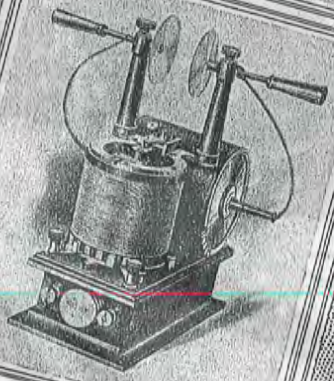


Fig. 6. Small oscillator for production of ozone

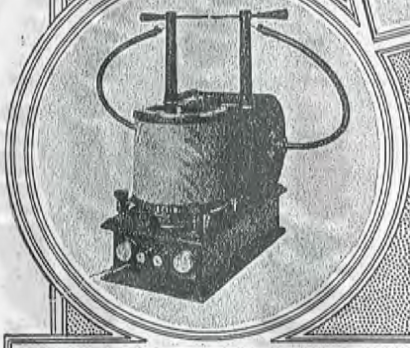


Fig. 7. Large Tesla Transformer for various purposes

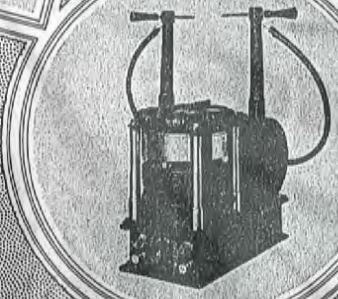


Fig. 8. Tesla Transformer with rotary break for wireless

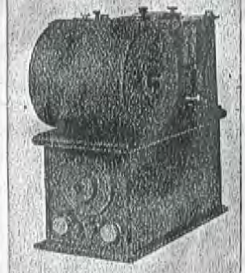
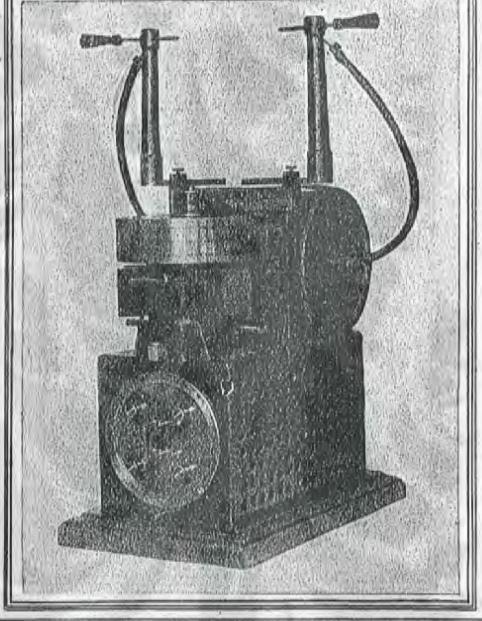


Fig. 9. Tesla Transformer with mercury interrupter

Fig. 10. Large Tesla Transformer with hermetically sealed mercury interrupter

Fig. 12. Another type of Tesla Transformer with sealed mercury interrupter



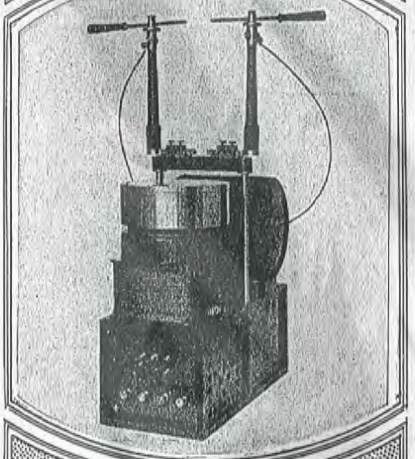
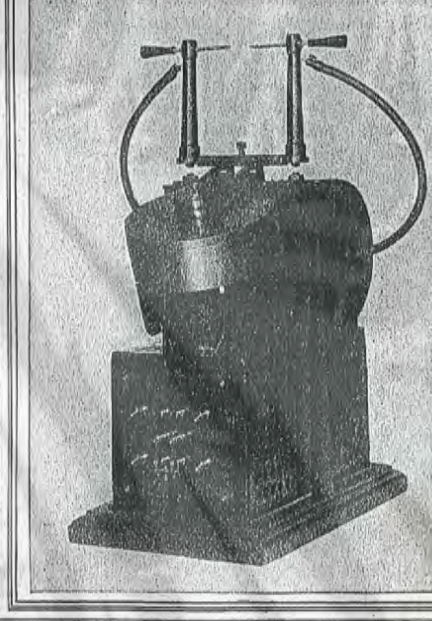


Fig. 11. Tesla Transformer with sealed mercury interrupter for low tension work



Electrical Oscillators

By NIKOLA TESLA

MR. TESLA makes a very important contribution to the electrical arts with this article.

The pioneer of all high frequency apparatus divulges much that is new and startling in these pages. Few people realize the enormous value of Mr. Tesla's machines and the many different important uses to which they can be applied in our everyday lives. New and startling uses are being found every year for these machines.

It is characteristic of Mr. Tesla that he has developed and actually built an astounding variation of these machines, and we regret that we can publish only a very few of the more important models.

Most of the Tesla coils shown have never been publisht before. —EDITOR.

FEW fields have been opened up the exploration of which has proved as fruitful as that of high frequency currents. Their singular properties and the spectacular character of the phenomena they presented immediately commanded universal attention. Scientific

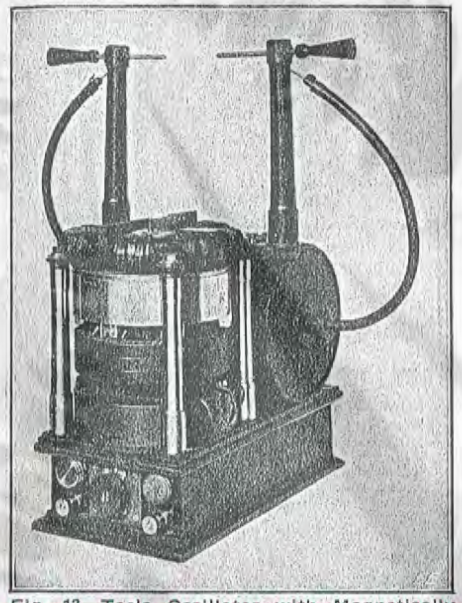


Fig. 13—Tesla Oscillator with Magnetically Controlled, Sealed Mercury Interrupter.

men became interested in their investigation, engineers were attracted by their commercial possibilities, and physicians recognized in them a long-sought means for effective treatment of bodily ills. Since the publication of my first researches in 1891, hundreds of volumes have been written on the subject and many invaluable results obtained thru the medium of this new agency. Yet, the art is only in its infancy and the future has incomparably bigger things in store.

From the very beginning I felt the necessity of producing efficient apparatus to meet a rapidly growing demand and during the eight years succeeding my original announcements I developed not less than fifty types of these transformers or electrical oscillators, each complete in every detail and refined to such a degree that I could not materially improve any one of them today. Had I been guided by practical considerations I might have built up an immense and profitable business, incidentally rendering important services to the world. But the force of circumstances and the ever enlarging vista of greater achievements turned my efforts in other directions. And so it comes that instruments will shortly be placed on the market which, oddly enough, were perfected twenty years ago!

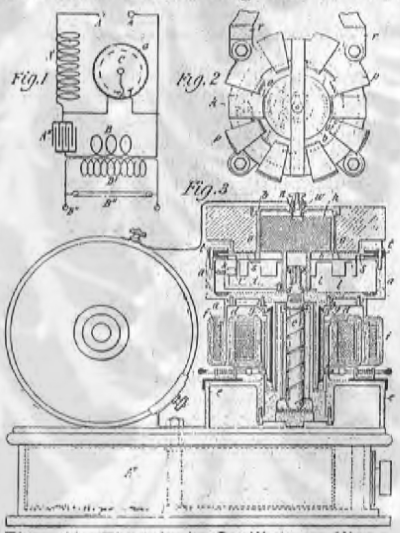


Fig. 14—Electrical Oscillator, Illustrated in Fig. 13, Showing Details and Circuit Connections.

These oscillators are expressly intended to operate on direct and alternating lighting circuits and to generate damped and undamped oscillations or currents of any frequency, volume and tension within the widest limits. They are compact, self-contained, require no care for long periods of time and will be found very convenient and useful for various purposes as, wireless telegraphy and telephony; conversion of electrical energy; formation of chemical compounds thru fusion and combination; synthesis of gases; manufacture of ozone; lighting; welding; municipal, hospital, and domestic sanitation and sterilization, and numerous other applications in scientific laboratories and industrial institutions. While these transformers have never been described before, the general principles underlying them were fully set forth in my publisht articles and patents, more particularly those of September 22, 1896, and it is thought, therefore, that the appended photographs of a few types, together with a short explanation, will convey all the information that may be desired.

The essential parts of such an oscillator are: a condenser, a self-induction coil for

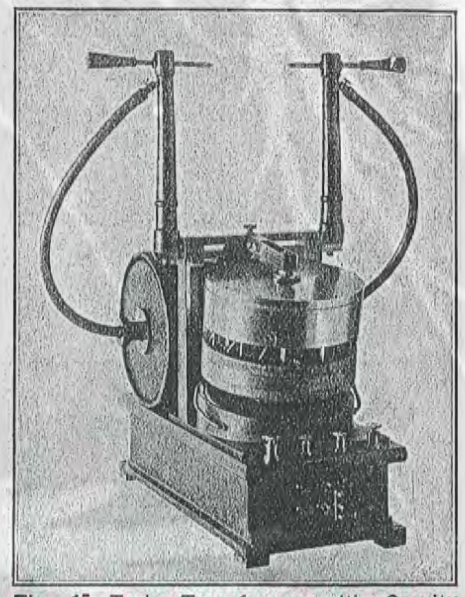


Fig. 15—Tesla Transformer with Gravity Controlled, Sealed Mercury Interrupter.

charging the same to a high potential, a circuit controller, and a transformer which is energized by the oscillatory discharges of the condenser. There are at least three, but usually four, five or six, circuits in tune and the regulation is effected in several ways, most frequently merely by means of an adjusting screw. Under favorable conditions an efficiency as high as 85% is attainable, that is to say, that percentage of the energy supplied can be recovered in the secondary of the transformer. While the chief virtue of this kind of apparatus is obviously due to the wonderful powers of the condenser, special qualities result from concatenation of circuits under observance of accurate harmonic relations, and minimization of frictional and other losses which has been one of the principal objects of the design.

(*Continued on page 259*)

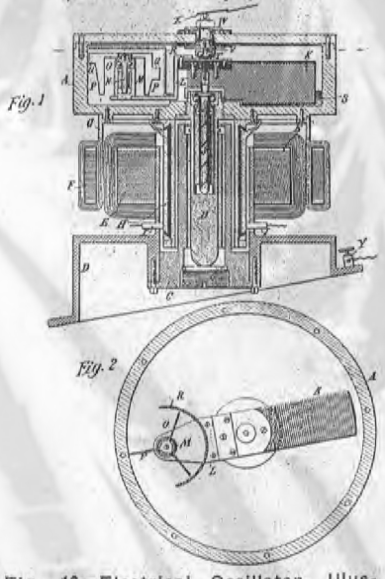


Fig. 16—Electrical Oscillator, Illustrated in Fig. 15, Showing Details of Motor and Break Mechanism.

SPECIAL NOTICE

Last month we announced another special feature article by Mr. Tesla, which altho made in good faith by us was not authorized by him. Due to very important duties of Mr. Tesla, it was impossible for him to furnish his historical article this month, so the special feature article publisht on this page takes its place. An important historical article will appear in the August issue.—Editor.

Electrical Oscillators

By Nikola Tesla

(Continued from page 229)

Broadly, the instruments can be divided into two classes: one in which the circuit controller comprises solid contacts, and the other in which the make and break is effected by mercury. Figures 1 to 8, inclusive, belong to the first, and the remaining ones to the second class. The former are capable of an appreciably higher efficiency on account of the fact that the losses involved in the make and break are reduced to the minimum and the resistance component of the damping factor is very small. The latter are preferable for purposes requiring larger output and a great number of breaks per second. The operation of the motor and circuit controller of course consumes a certain amount of energy which, however, is the less significant the larger the capacity of the machine.

In Fig. 1 is shown one of the earliest forms of oscillator constructed for experimental purposes. The condenser is contained in a square box of mahogany upon which is mounted the self-induction or charging coil wound, as will be noted, in two sections connected in multiple or series according to whether the tension of the supply circuit is 110 or 220 volts. From the box protrude four brass columns carrying a plate with the spring contacts and adjusting screws as well as two massive terminals for the reception of the primary of the transformer. Two of the columns serve as condenser connections while the other pair is employed to join the binding posts of the switch in front to the self-inductance and condenser. The primary coil consists of a few turns of copper ribbon to the ends of which are soldered short rods fitting into the terminals referred to. The secondary is made in two parts, wound in a manner to reduce as much as possible the distributed capacity and at the same time enable the coil to withstand a very high pressure between its terminals at the center, which are connected to binding posts on two rubber columns projecting from the primary. The circuit connections may be slightly varied but ordinarily they are as diagrammatically illustrated in the ELECTRICAL EXPERIMENTER for May on page 89, relating to my oscillation transformer photograph of which appeared on page 16 of the same number. The operation is as follows: When the switch is thrown on, the current from the supply circuit rushes thru the self-induction coil, magnetizing the iron core within and separating the contacts of the controller. The high tension induced current then charges the condenser and upon closure of the contacts the accumulated energy is released thru the primary, giving rise to a long series of oscillations which excite the tuned secondary circuit.

This device has proved highly serviceable in carrying on laboratory experiments of all kinds. For instance, in studying phenomena of impedance, the transformer was removed and a bent copper bar inserted in the terminals. The latter was often replaced by a large circular loop to exhibit inductive effects at a distance or to excite resonant circuits used in various investigations and measurements. A transformer suitable for any desired performance could be readily improvised and attached to the terminals and in this way much time and labor was saved. Contrary to what might be naturally expected, little trouble was experienced with the contacts, altho the currents thru them were heavy, namely, proper conditions of resonance existing, the great flow occurs only when the circuit is closed and no destructive arcs can develop. Origi-

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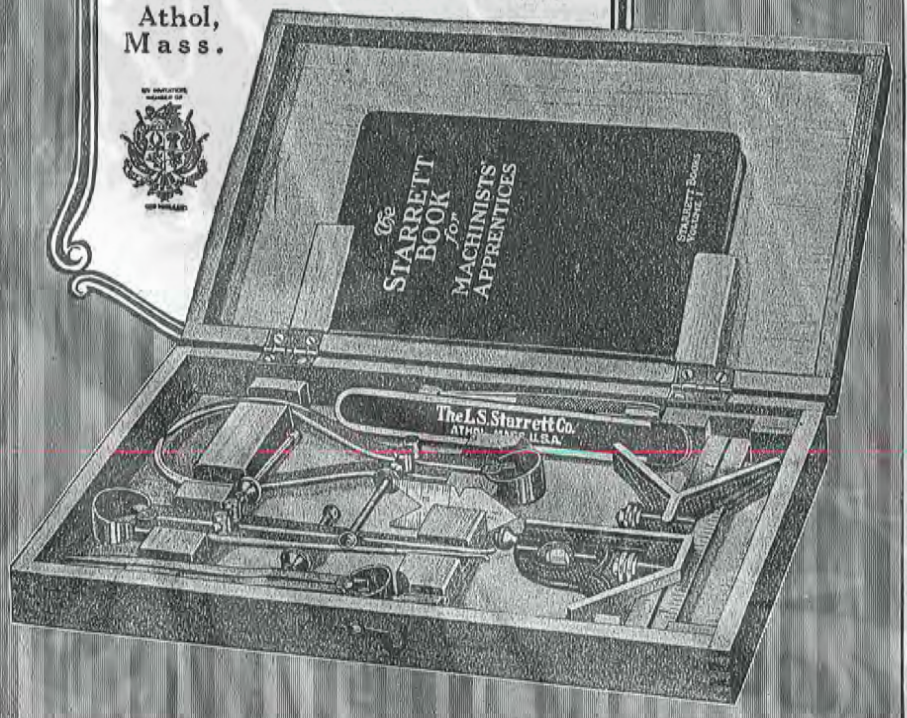
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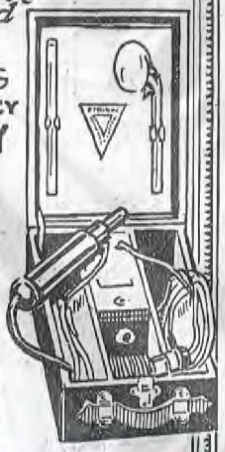
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nally I employed platinum and iridium tips but later replaced them by some of meteorite and finally of tungsten. The last have given the best satisfaction, permitting working for hours and days without interruption.

Fig. 2 illustrates a small oscillator designed for certain specific uses. The underlying idea was to attain great activities during minute intervals of time each succeeded by a comparatively long period of inaction. With this object a large self-induction and a quick-acting break were employed owing to which arrangement the condenser was charged to a very high potential. Sudden secondary currents and sparks of great volume were thus obtained, eminently suitable for welding thin wires, flashing lamp filaments, igniting explosive mixtures and kindred applications. The instrument was also adapted for battery use and in this form was a very effective igniter for gas engines on which a patent bearing number 609,250 was granted to me August 16, 1898.

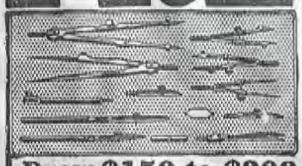
Fig. 3 represents a large oscillator of the first class intended for wireless experiments, production of Röntgen rays and scientific research in general. It comprises a box containing two condensers of the same capacity on which are supported the charging coil and transformer. The automatic circuit controller, hand switch and connecting posts are mounted on the front plate of the inductance spool as is also one of the contact springs. The condenser box is equipt with three terminals, the two external ones serving merely for connection while the middle one carries a contact bar with a screw for regulating the interval during which the circuit is closed. The vibrating spring itself, the sole function of which is to cause periodic interruptions, can be adjusted in its strength as well as distance from the iron core in the center of the charging coil by four screws visible on the top plate so that any desired conditions of mechanical control might be secured. The primary coil of the transformer is of copper sheet and taps are made at suitable points for the purpose of varying, at will, the number of turns. As in Fig. 1 the inductance coil is wound in two sections to adapt the instrument both to 110 and 220 volt circuits and several secondaries were provided to suit the various wave lengths of the primary. The output was approximately 500 watt with damped waves of about 50,000 cycles per second. For short periods of time undamped oscillations were produced in screwing the vibrating spring tight against the iron core and separating the contacts by the adjusting screw *which also performed the function of a key.* With this oscillator I made a number of important observations and it was one of the machines exhibited at a lecture before the New York Academy of Sciences in 1897.

Fig. 4 is a photograph of a type of transformer in every respect similar to the one illustrated in the May, 1919, issue of the ELECTRICAL EXPERIMENTER to which reference has already been made. It contains the identical essential parts, disposed in like manner, but was specially designed for use on supply circuits of higher tension, from 220 to 500 volts or more. The usual adjustments are made in setting the contact spring and shifting the iron core within the inductance coil up and down by means of two screws. In order to prevent injury thru a short-circuit, fuses are inserted in the lines. The instrument was photographed in action, generating undamped oscillations from a 220 volt lighting circuit.

Fig. 5 shows a later form of transformer principally intended to replace Rhumkorf coils. In this instance a primary is employed, having a much greater number of turns and the secondary is closely linked with the same. The currents developed in the latter, having a tension of from 10,000 to 30,000 volts, are used to charge con-

(Continued on page 276)

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Electrical Oscillators

By Nikola Tesla

(*Continued from page 260*)

densers and operate an independent high frequency coil as customary. The controlling mechanism is of somewhat different construction but the core and contact spring are both adjustable as before.

Fig. 6 is a small instrument of this type, particularly intended for ozone production or sterilization. It is remarkably efficient for its size and can be connected either to a 110 or 220 volt circuit, direct or alternating, preferably the former.

In Fig. 7 is shown a photograph of a

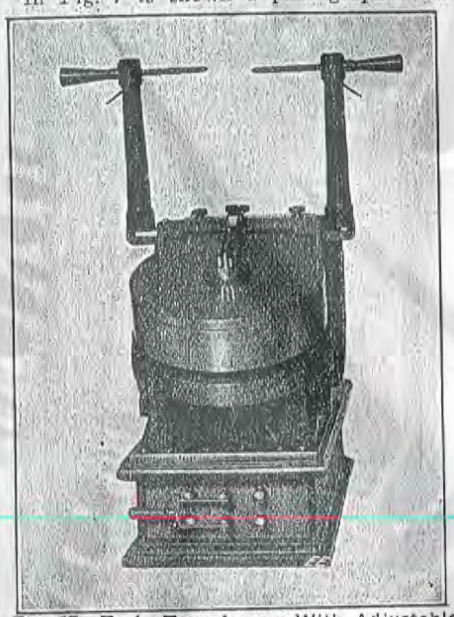


Fig. 17. Tesla Transformer With Adjustable Mercury Controller.

larger transformer of this kind. The construction and disposition of the parts is as before but there are two condensers in the box, one of which is connected in the circuit as in the previous cases, while the other is in shunt to the primary coil. In this manner currents of great volume are produced in the latter and the secondary effects are accordingly magnified. The introduction of an additional tuned circuit secures also other advantages but the adjustments are rendered more difficult and for this reason it is desirable to use such an instrument in the production of currents of a definite and unchanging frequency.

Fig. 8 illustrates a transformer with rotary break. There are two condensers of the same capacity in the box which can be connected in series or multiple. The charging inductances are in the form of two long spools upon which are supported the secondary terminals. A small direct current motor, the speed of which can be varied within wide limits, is employed to drive a specially constructed make and break. In other features the oscillator is like the one illustrated in Fig. 3 and its operation will be readily understood from the foregoing. This transformer was used in my wireless experiments and frequently also for lighting the laboratory by my vacuum tubes and was likewise exhibited at my lecture before the New York Academy of Sciences above mentioned.

Coming now to machines of the second class, Fig. 9 shows an oscillatory transformer comprising a condenser and charging inductance enclosed in a box, a transformer and a mercury circuit controller, the latter being of a construction described for the first time in my patent No. 609,251 of August 16, 1898. It consists of a motor driven hollow pulley containing a small quantity of mercury which is thrown outwardly against the walls of the vessel by centrifugal force and entrains a contact wheel which periodically closes and opens the condenser circuit. By means of adjusting screws above the pulley, the depth of immersion of the vanes and consequently, also, the duration of each contact can be varied at desire and thus the intensity of the effects and their character controlled. This form of break has given thoro satisfaction, working continuously with currents of from 20 to 25 amperes. The number of interruptions is usually from 500 to 1,000 per second but higher frequencies are practicable. The space occupied is about 10" x 8" x 10" and the output approximately ½ K.W.

In the transformer just described the break is exposed to the atmosphere and a slow oxidation of the mercury takes place. This disadvantage is overcome in the instrument shown in Fig. 10, which consists of a perforated metal box containing the condenser and charging inductance and carrying on the top a motor driving the break, and a transformer. The mercury break is of a kind to be described and operates on the principle of a jet which establishes, intermittently, contact with a rotating wheel in the interior of the pulley. The stationary parts are supported in the vessel on a bar passing thru the long hollow shaft of the motor and a mercury seal is employed to effect hermetic closure of the chamber enclosing the circuit controller. The current is led into the interior of the pulley thru two sliding rings on the top which are in series with the condenser and primary. The exclusion of the oxygen is a decided improvement, the deterioration of the metal and attendant trouble being eliminated and perfect working conditions continuously maintained.

Fig. 11 is a photograph of a similar oscillator with hermetically inclosed mercury break. In this machine the stationary parts of the interrupter in the interior of the pulley were supported on a tube thru which was led an insulated wire connecting to one terminal of the break while the other was in contact with the vessel. The sliding rings were, in this manner, avoided and the construction simplified. The instrument was designed for oscillations of lower tension and frequency requiring primary currents of comparatively smaller amperage and was used to excite other resonant circuits.

Fig. 12 shows an improved form of oscillator of the kind described in Fig. 10, in which the supporting bar thru the hollow motor shaft was done away with, the device pumping the mercury being kept in position by gravity, as will be more fully explained with reference to another figure. Both the capacity of the condenser and primary turns were made variable with the view of producing oscillations of several frequencies.

Fig. 13 is a photographic view of another form of oscillatory transformer with hermetically sealed mercury interrupter, and Fig. 14 diagrams showing the circuit connections and arrangement of parts reproduced from my patent, No. 609,245, of August 16, 1898, describing this particular device. The condenser, inductance, transformer and circuit controller are disposed as before, but the latter is of different construction, which will be clear from an inspection of Fig. 14. The hollow pulley *a* is secured to a shaft *c* which is mounted in a vertical bearing passing thru the stationary field magnet *d* of the motor. In the interior of the vessel is supported, on frictionless bearings, a body *h* of magnetic material which is surrounded by a dome *b* in the center of a laminated iron ring, with pole pieces *aa* wound with energizing coils *p*. The ring is supported on four columns and, when magnetized, keeps the body *h* in position while the pulley is rotated. The latter is of steel, but the dome is preferably made of German silver burnt black by acid or nickeled. The body *h* carries a short tube *k* bent, as indicated, to catch the fluid as it is whirled around, and project it against the teeth of a wheel fastened to the pulley. This wheel is insulated and contact from it to the external circuit is established thru a mercury cup. As the pulley is rapidly rotated a jet of the fluid is thrown against the wheel, *thus making and breaking contact about* 1,000 *times per second.* The instrument works silently and, owing to the absence of all deteriorating agents, keeps continually clean and in perfect condition. The number of interruptions per second may be much greater, however, so as to make the currents suitable for wireless telephony and like purposes.

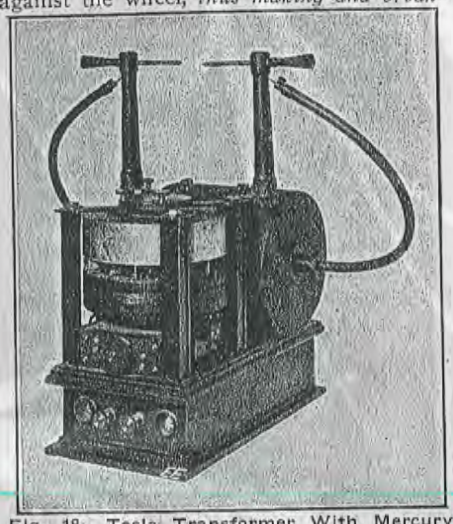


Fig. 18. Tesla Transformer With Mercury Jet Interrupter.

A modified form of oscillator is represented in Figs. 15 and 16, the former being a photographic view and the latter a diagrammatic illustration showing the arrangement of the interior parts of the controller. In this instance the shaft *b* carrying the vessel *a* is hollow and supports, in frictionless bearings, a spindle *j* to which is fastened a weight *k*. Insulated from the latter, but mechanically fixt to it, is a curved arm L upon which is supported, freely rotatable, a break-wheel with projections QQ. The wheel is in electrical connection with the external circuit thru a mercury cup and an insulated plug supported from the top of the pulley. Owing to the inclined position of the motor the weight *k* keeps the break-wheel in place by the force of gravity and as the pulley is rotated the circuit, including the condenser and primary coil of the transformer, is rapidly made and broken.

Fig. 17 shows a similar instrument in which, however, the make and break device is a jet of mercury impinging against an insulated toothed wheel carried on an insulated stud in the center of the cover of the pulley as shown. Connection to the condenser circuit is made by brushes bearing on this plug.

Fig. 18 is a photograph of another transformer with a mercury circuit controller of the wheel type, modified in some features on which it is unnecessary to dwell.

These are but a few of the oscillatory transformers I have perfected and constitute only a small part of my high frequency apparatus of which I hope to give a full description, when I shall have freed myself of pressing duties, at some future date.

TESLA COIL BUILDERS ASSOCIATION
3 AMY LANE
QUEENSBURY, NEW YORK, 12804
(518) 792-1003



August 24, 2006

Hello Jeff,

Received your surprise package and communication. The many photo/illustrations and info will be reviewed several times. I do appreciate you looking into that mysterious light bulb/spark gap as I could make neither head nor tail out of it. I think the guy was just spinning the reporter a bit. But then, if anyone can resolve it I'm sure it will be you.

I've been bogged down with several projects that seem to be going nowhere fast so I probably won't get to the violet ray experiment this summer.

I haven't heard from Gary Peterson for some time but during our last communication, he said he would be giving a lecture at the Tesla conference being held in Brookhaven, NY (I think that's where it is being held). I didn't know that Steve Elswick is still in the Tesla promoting business. We weren't on very good terms for several reasons. As I recall, his character was questionable (but I'll not go into it now). But if you are being paid for providing services, I'd suggest you get your money up front.

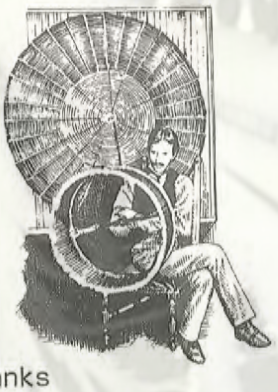
I was shocked to learn that the old Electrical Experimenter magazines are so valuable (especially those with a connection to Tesla). I see them on Ebay every once in a while but the prices usually run$30-40. Guess I'll have to put mine on the market (someday).

I have always been intrigued by Tesla's "Egg of Columbus" demo. Back in my early teaching career, I attempted to replicate it with lower power inputs. An engineer told me that Tesla used a lot of power to get the result and that a "huge" capacitor was needed. Subsequently, I really didn't make much headway (until returning to the problem years later). Actually, very little power is needed, and that "huge" capacitor was not as huge as I expected. I even wrote up an article on it. The only problem I had was to find a metal egg. One day, as I was working with some steel wool, the light went on. I immediately took a plastic Easter egg and stuffed it with steel wool. Voila! It works. (see enclosed photos).

I'll be leaving tomorrow for Ed Wingate's Teslathon in Brockport, NY (western part of the state). I'll let you know if there is anything worth talking about.

Harry

TESLA ELECTRICAL EXPERIMENTERS
3 AMY LANE
QUEENSBURY, NEW YORK 12804
(518) 792-1003



January 9, 2009

Jeff Behary,

Received your holiday email and follow-up package of photos. Thanks for keeping in contact. It's always interesting seeing the amazing apparatus in your collection. I've remarked to Ruth that if we ever get to Florida that I would make it my objective to visit your Turn of the Century Electrotherapy Museum.

We're now in the middle of our winter months and all activity has come to a halt. My most active exercise is trying to find a warm corner in the house. It's been very cold here. Also, we get a regular visit by snow storms. Got a guest room in your Museum (ha)? I'll polish all of your discharge spheres in lieu of payment of rent. (more laughs).

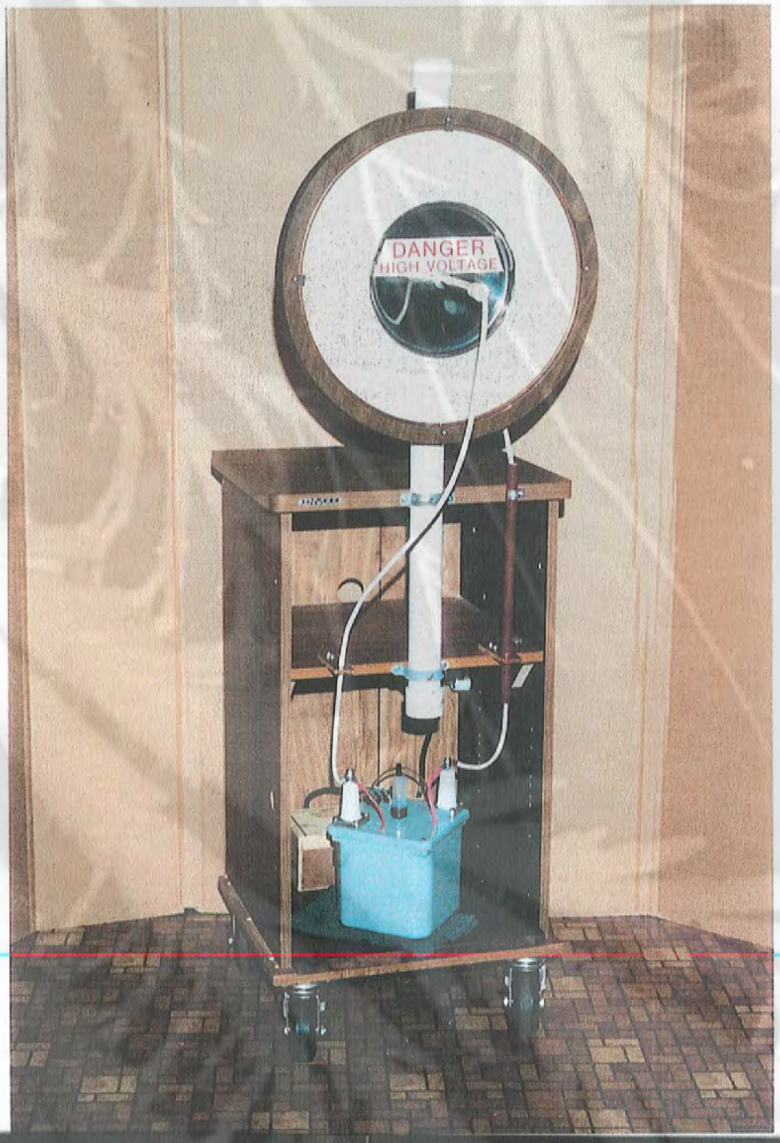
The bad news is that I've had some health problems that prevent me from making any progress in experimentation. An MRI showed no stroke, tumor, or abberations. And the docs don't know if anything can be done. Ruth does all the driving as I have also developed a condition of double vision. New glasses haven't helped. I must do my typing and reading with one eye covered. The good news is that the days are getting longer. I feel better already.

You may have noticed that Cameron Prince has digitized all of the TCBA newsletters and made them available on line (for free) to anyone who wishes to read or download them. Just the other day, a friend notified me that there was a controversy on the Teslanet regarding Elihu Thomson and Nikola Tesla. Why argue about it when I covered the discussion completely in Volume 10, #2. One TC writer wanted to know the capacitance of Thomson's large Tesla coil. That's covered in the same issue, too. So, Cameron has done coilers a great favor with his website.

Can you provide any news regarding Robert Campbell's book? I was hoping to see it in print by this time.

I apologize for not being able to reciprocate with equally interesting photos. Wishing you and your family a healthy and enjoyable new year.

Harry Goldman



my mini version of Stricktaden's lightning screen.



No. 817,976. PATENTED APR. 17, 1906.

T. B. KINRAIDE.

ULTRA VIOLET LAMP.

APPLICATION FILED JUNE 12, 1905.

Fig. 1.

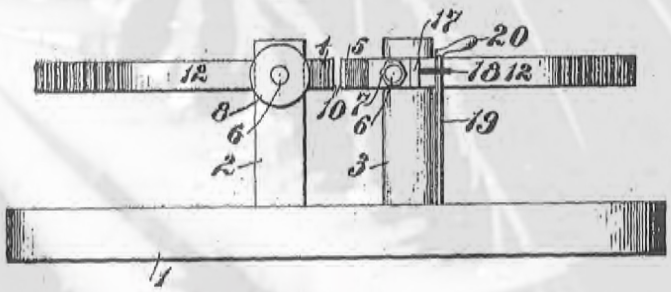
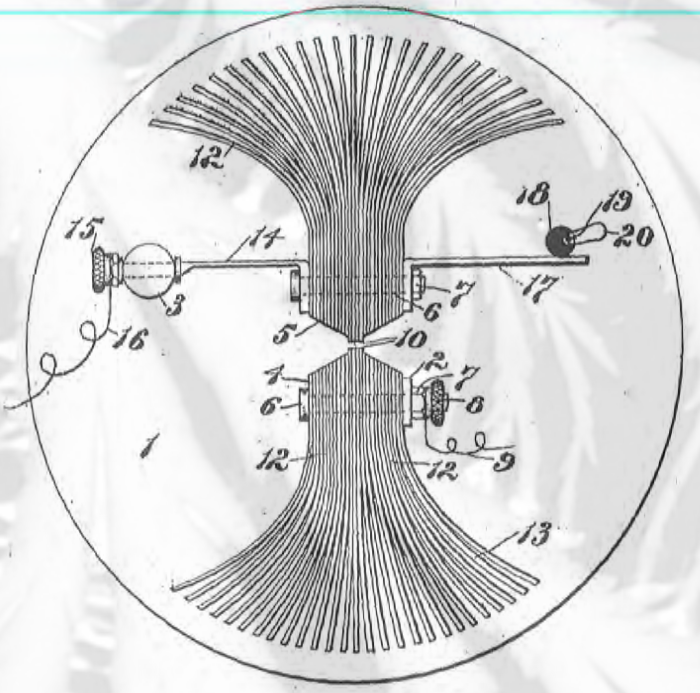


Fig. 2.



Witnesses:
Walter H. Naylor.
M. A. Jones.

Inventor:
Thomas B. Kinraide,
by Geo. S. Maxwell,
Attorney.

UNITED STATES PATENT OFFICE.

THOMAS B. KINRAIDE, OF JAMAICA PLAIN, MASSACHUSETTS.

ULTRA-VIOLET LAMP.

No. 817,976. Specification of Letters Patent. Patented April 17, 1906.

Application filed June 12, 1905. Serial No. 264,875.

To all whom it may concern:

Be it known that I, THOMAS B. KINRAIDE, a citizen of the United States, residing at Jamaica Plain, in the county of Suffolk and State of Massachusetts, have invented an Improvement in Ultra-Violet Lamps, of which the following description, in connection with the accompanying drawings, is a specification, like figures on the drawings representing like parts.

The object of my invention is to produce a simple and inexpensive lamp for ultra-violet-ray work capable of comparatively continuous use.

I have found that in use the quality of the light produced by the usual ultra-violet lamps (operated by a condenser-discharge) decreases as the lamps get heated, and the ultra-violet rays quickly cease on overheating of the lamps, so that it is practically impossible to maintain the ultra-violet ray continuously for effective work for any comparatively long period; yet it is desirable, if not necessary, in many instances that the production of this ray shall be not only continuous, but substantially uniform and reliable. Accordingly I have devised the hereinafter-described mechanism for accomplishing the desired object as above explained.

Referring to the drawings, in which I have shown a preferred embodiment of my invention, Figure 1 represents the essentials thereof in side elevation, and Fig. 2 is a top plan view thereof.

In carrying out my invention I have eliminated all needless appurtenances and have secured my object by providing the required electrodes (preferably iron) capable of automatically maintaining themselves within the range of maximum heating, thereby producing the continuous and uniform ultra-violet condition desired.

Mounted on a suitable base 1 are opposite standards 2 3, supporting the opposite electrodes 4 5, the former in fixed position and the latter in adjustable position. Each electrode is composed of a large number of thin plates clamped compactly together adjacent one end by suitable means, as by a bolt 6, which in the adjustable electrode is shown as simply provided with a tightening-nut 7 and in the fixed electrode is shown as provided also with a binding-nut 8 for holding in place a terminal wire 9. The central plates 10 are composed of material suitable for producing to the best advantage the desired results, such as iron or steel, and at the opposite sides thereof are similar thin plates 12 of like material or of copper, aluminium, or any heat-dissipating substance, said plates converging as close to the discharge-points of the electrodes as feasible without interfering with the proper working thereof and at their opposite ends extending rearwardly from the arcing-point to a considerable distance and separated from each other by fan-like formation, as clearly shown at 13, thereby forming between them a multitude of air-passages, which formation under the heating influence of the electric current causes a rapid flow of cooling-air, tending to absorb and remove the heat radiated by the flaring rearwardly-extending plates 12.

I have found in practice that the foregoing mechanism will rise simply to a given working temperature and that in an ordinary atmosphere it can be run with maximum efficiency continuously without exceeding said temperature. The tightly-compressed thin plates readily transmit from one to another the heat from the central discharge-electrodes 10 and divide said heat among the individual plates 12, conveying it rapidly rearwardly and dissipating it uniformly into the surrounding air, thereby constantly drawing away from the electrodes the heat which would otherwise quickly render them inoperative for producing ultra-violet rays.

The adjustable electrode is supported on a yielding spring-bar 14, fast in the upper end of the post 3 and provided with a binding-nut 15 for securing a circuit-terminal 16. The spring 14 is under constant tendency to swing its electrode rearwardly. Said electrode is provided with a rigid arm 17, adjustable by means of an eccentric 18 on a post 19, operated by a handle 20, so that as the eccentric is swung forward the electrode 5 is correspondingly adjusted toward the opposite electrode 4, or as the eccentric is swung back the electrode 5 is correspondingly removed from the fixed electrode 4.

I prefer the form of the electrode as shown adjacent the discharge-area, as it conduces to the best results, the massing of the metal at this point not only taking care of the heat, but being especially efficient with reference to the current.

My mechanism also affords convenient and inexpensive means for renewing the electrodes, as it becomes necessary merely to remove the thin plates or strips 10 or part of

them only, as they become burned or corroded, and so likewise with any of the heat-dissipating plates or vanes 12.

It will be understood that I am not limited to the constructional details herein set forth except as otherwise expressed in the claims, inasmuch as my invention is capable of a wide variety of embodiments without departing from the spirit and scope thereof.

Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. An ultra-violet lamp, comprising opposite electrodes, having central discharge-points, and provided with rearwardly-extending separated heat-dissipating members for conducting the heat rearwardly from said points and maintaining an even temperature of the discharge-points in operation.

2. An ultra-violet lamp, comprising opposite electrodes, having central discharge-points and heat-absorbing masses surrounding said discharge-points and provided with rearwardly-extending, separated, heat-dissipating members.

3. An ultra-violet lamp, comprising opposite electrodes, consisting of a mass of metal at the discharge area and separated at the rear thereof into a multitude of diverging plates for dissipating the heat from said mass.

4. In an ultra-violet lamp, an electrode consisting of a plurality of metal plates clamped together in mutual contact at the discharge end thereof and spread apart from each other at the opposite end of said electrode.

5. In an ultra-violet lamp, an electrode having a wedge-shaped discharge end and a fan-shaped rear end, composed of a large number of thin metal plates, means clamping said plates tightly together at the said discharge end, said plates being bent apart from each other to form intervening air-spaces at said rear end.

6. In an ultra-violet lamp, an electrode, consisting of a plurality of thin plates clamped tightly together at one end and separated from each other at the rear thereof, the inner plates thereof consisting of conductors effective for producing ultra-violet rays and extending forward to constitute discharge-points, and the remaining plates consisting of conductors effective for radiating heat.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THOMAS B. KINRAIDE.

Witnesses:
GEO. H. MAXWELL,
M. A. JONES.

LIGHTNING SCREEN

This lightning screen project is based on a design created by Kenneth Strickfaden and used by him in many Hollywood horror and science fiction films [Figure 1]. Although it represents a principle of physics centuries old, anyone with a passion for lightning, high voltage phenomena, and electrical history will find this device to be an impressive performer.

By Harry Goldman



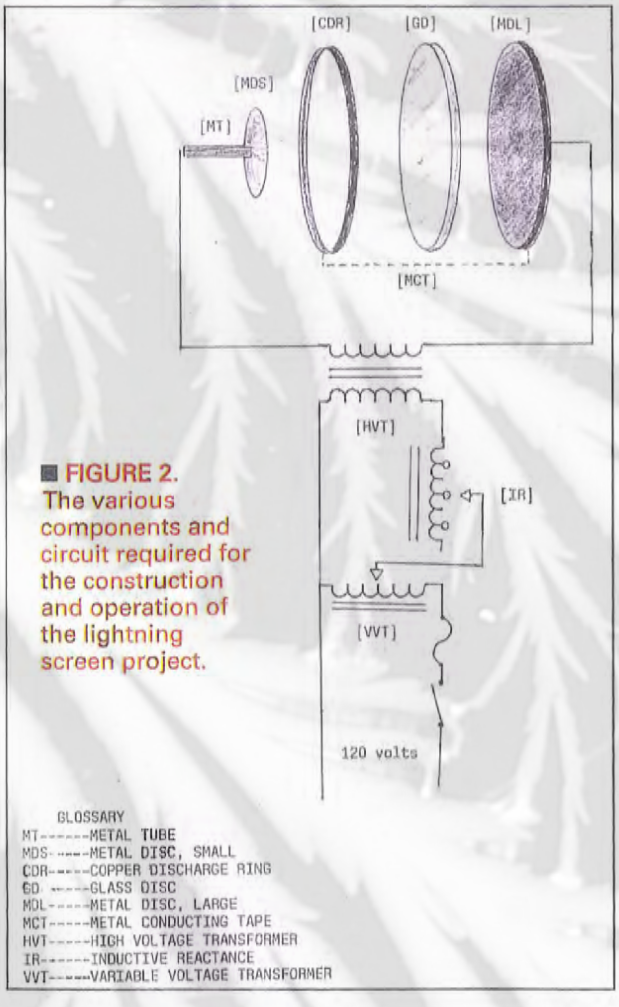
■ FIGURE 1. Kenneth Strickfaden, special electrical effects wizard of Hollywood's golden age, is shown operating the lightning screen used in numerous mad scientist movies.

Technically, it consists of a simple two-plate capacitor made from metal discs with a disc of glass as the dielectric. Think of it as a flattened Leyden jar[1]. The challenging part is not so much electrical as it is in assembling and mounting the components [**Figure 2**].

The large metal disc [MDL], glass disc [GD], and copper discharge ring [CDR] are identical in overall diameter. The smaller metal disc [MDS] is not critical but generally one-third the diameter of the large metal disc. The copper discharge ring is formed from one-quarter inch [ID] or larger tubing. Several short lengths of metallic conducting tape [MCT] — strategically placed at equidistant points — create an electrical connection between the large metal disc and the copper discharge ring.

The power source required is dependent upon the overall dimensions of your project. Large systems demand voltages of 30 kV or up. Smaller projects can function at one-half those potentials. This project is powered by an oil-immersed 65 kV x-ray transformer [**Figure 3**]. However, it will fill the screen with discharges while running at only 50-55% of its rating [**Figure 4**]. The final dimensions of your project will be determined by ambition, imagination, craftsmanship skills, and experience with high voltage electricity. Strickfaden's lightning screens — constructed from discarded and cobbled-up parts — measured approximately 44" across. The screen for this project is a modest 16" [OD] for the large discs with a smaller disc of 8" [**Figure 5**]. Now that I have a feel for what my screen can do, I plan to replace the central disc with one having a 5-6" cross-section. This change will result in an increase in the sparking distances and with (no doubt) an accompanying rise in the crackling noise levels.

In assembling the material for this project, I followed



■ FIGURE 2. The various components and circuit required for the construction and operation of the lightning screen project.

Strickfaden's practice of searching out ready-made items that might be applied to its construction. The supporting framework used here appears to have previously served as a Lazy Susan food tray. The entire assembly is mounted on a mobile cabinet originally designed for audio equipment. Both the Lazy Susan and equipment cabinet were garage sale purchases. Any craftsman skilled in woodworking will have the tools and expertise to design and fashion their own supporting structures. Plus, we've seen what marvelous structures can be fashioned from PVC pipe.

The metal rod or tube [MT] extending from the small central disc can either be soldered, welded, or bolted in place. I chose the latter by pressing a threaded shaft coupler into one end of the tube and secured it to the disc with a flathead bolt. It was necessary to form a small depression around the disc's center hole so the head of the bolt would be in the same plane with its bottom surface. The small central disc is attached to the glass with double-sided tape. It must be mounted at the exact center of the glass disc. An electrical connection was made using a toggle bolt. Once forced into the tube, the toggle stays fixed by friction. It can be easily removed. The entire screen assembly is held in place with simple retainers of non-conducting materials such as plastic, bakelite, wood, etc. [**Figure 6**].

I found that discharges emanating from the flat center disc show a tendency for hugging to the surface of the glass. This can create enough heat to eventually crack the glass. By substituting a sturdy metal pie, pizza, or dinner plate, the chance of overheating the glass is greatly reduced. The raised "wings" of the plate position the edge or discharge surfaces above the glass.

Heat resistant (tempered) glass is a better choice of material when it comes to lightning screens. Round tempered glass intended for protecting table surfaces can be obtained from your local big box store (Target, etc.). However, you will have to use it in the size at which it comes as tempered glass cannot be cut down to size. If you are thinking of ordering a custom-sized tempered glass product from a local glass firm, brace yourself when the clerk quotes the price. I used 3/16" common glass for the dielectric. Avoid plain windowpane glass.

Discharges between the center disc and the copper ring are not only impressive but also very loud (ear protectors recommended). By again taking a tip from Strickfaden, the effect is further enhanced when coating the large metal disc with a special luminous paint or paper. The sparks will temporarily leave their signature on the luminous material. A self-stick luminous plastic product can be obtained from Extreme Glow, P.O. Box 3037, Tupelo, MS 38803. The USA phone is 1-888-748-4755. Luminous paints are available from any craft or department store. I did not try paints so I am unable to tell you just how well they work in this situation.

The best way to demonstrate the full effect of the discharges is to operate the screen in total or near-total darkness. Short runs not only create the best after-glow effect but reduce the chance of overheating the glass. Long exposures tend to blur the individual lightning trails on the glow product. Interestingly, there is a simple sketch of a lightning screen on page 180 of *Kenneth Strickfaden, Dr. Frankenstein's Electrician* (McFarland, 2005) suggesting the use of a mirror as the dielectric.

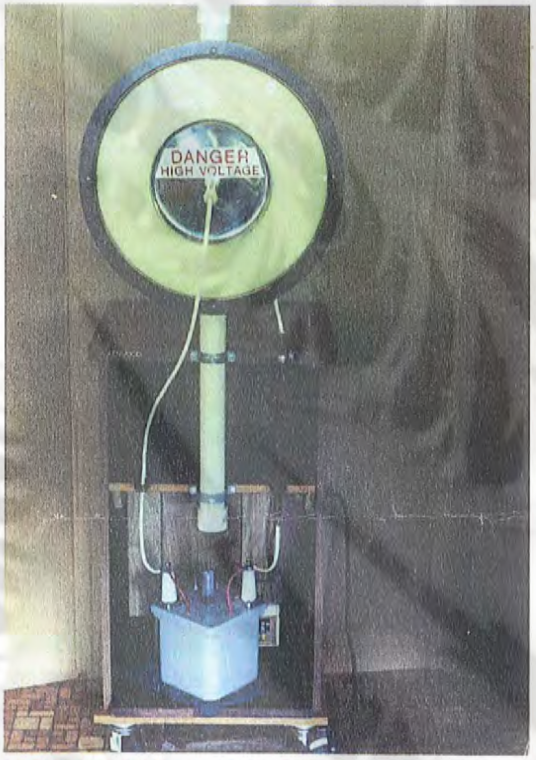


FIGURE 3. The 65 kV (oil immersed) x-ray transformer used to power the lightning screen. An inductive reactance is hooked in series to limit the current draw.

To prevent electrical currents from running wild and tripping circuit breakers, an inductive reactance [IR] or choke must be inserted in series with the 120 volt input line of the high voltage transformer [HVT]. I applied a multi-tapped, iron-cored inductor from an old medical machine [**Figure 7**]. The tap measuring 20 mH provided the best results. A simple reactance can be made by packing a one-inch by seven-inch plastic or phenolic tube with soft iron (coat hanger) wire cut to 6" lengths and winding it with no less than two layers of #14 or #16 copper conductor. Give each layer a wrapping of tape before continuing winding. Tapping the ends and center turn of the second layer will provide a choice of reactances [**Figure 8**]. In place of the core of wires, ferrite



FIGURE 4. The lightning screen's discharges are not only impressive but very loud.



■ FIGURE 5. The completed lightning screen project.



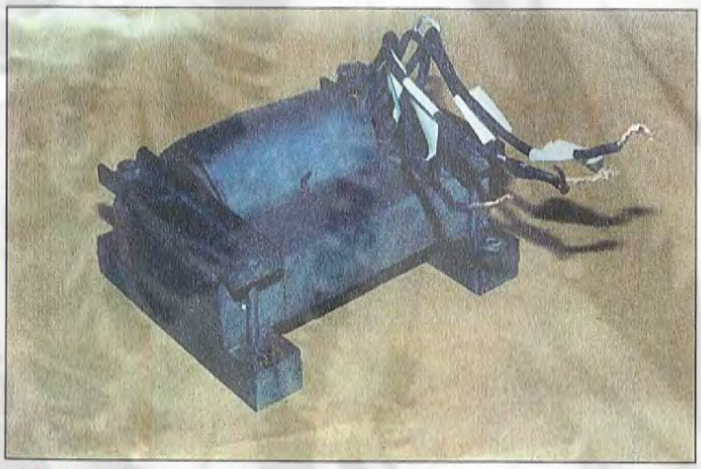
■ FIGURE 6. A close-up showing comparative sizes of the 16" and 8" discs. Also shown are plastic retaining clips to hold the disc in place. The luminous glow paper behind the glass disc provides the coloration.

rings can provide the electrical tinker with a superior inductor core product.

A simpler and less time-consuming method is to connect a 150 watt (or larger) incandescent bulb in series with the transformer input line. Another approach is to insert an electrical heating device (hot plate, toaster, etc.) or similar resistance in the circuit to act as a ballast. My project pulls between 5-7 amperes. No current control is required when screens are powered by current limiting ignition or neon sign transformers.

A piece of equipment not essential to the construction of a lightning screen – but which is highly recommended for its operation – is a variable voltage transformer [VVT] such as a variac, powerstat, etc. The VVT allows full control over operation of the screen and can assist in determining the correct amount of ballast. Too much ballast draws a near-zero current and produces very little sparking. A weak ballast will fill the screen with crackling discharges but at the expense of pulling an excessive current. The VVT allows the operator to find an acceptable balance. Lacking such a control requires energizing the circuit at full voltage. Although this procedure can create startling results, it is a practice I choose to avoid.

Variable transformers featuring both a voltmeter and ammeter are preferred over the single or non-metered models. Unfortunately, purchasing a dual meter VVT can be an expensive proposition. Even a used double-meter model – if one can be found – brings in big money. I surmounted the problem by purchasing a 7.5 ampere meterless VVT at a hamfest for less than $10. I mounted it within an old metal cabinet and added two inexpensive meters along with an inlet, outlet, switch, fuse, and pilot light, for a cost of less than $50. eBay is another good source for finding used variable transformers.



■ FIGURE 7. An inductive reactance was placed in series with the 120 volt line to control current draw. This unit was once a component part of an old medical machine.



■ FIGURE 8. An inductive reactance can be easily constructed using readily-available materials.

Finally, the lightning screen should not be confused with the safe, silent, plasma-like luminous discs which have become popular sales items at variety stores. On the contrary, the project described herein involves electrical potentials which are unforgiving to those who become careless in its operation. The good news is that the lightning screen is an alternating current capacitor with little – if any – residual charge remaining on the plates once it is shut down. Even so, experimenters must disconnect it from the power line when it becomes necessary to make adjustments or when not in use.

A remarkable person once declared, "No man is an island unto himself." That statement is certainly true in this endeavor and I gladly acknowledge the valuable input and assistance received from Steve Cole, Mitch Tilbury, and Suzanne Gaeta. **NV**

Footnotes

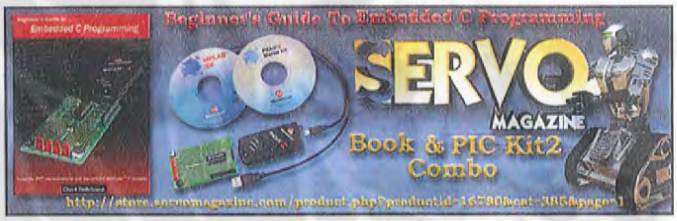
1) An early form of capacitor invented in 1745 in Leyden [Leiden], The Netherlands.

Harry Goldman can be contacted by sending correspondence to 3 Amy Lane, Queensbury, NY 12804.

PARTS LIST

Because of the nature of this project and the spirit in which it is intended, there is no formal parts list. This project can be made from used/collectable parts wherever they may be available, so it is up to the reader to gather the necessary components. Here's a basic list of some of the items I used in my build. The only item I purchased new was the glass disc.

- 3/16" x 16" diameter glass disc
- 65 kV x-ray transformer
- Inductive reactance, 20 mH
- Large metal disc 16" diameter
- Small metal serving dish 8" D
- Metal tube 4 3/4" x 8"
- 1/4" ID copper tubing
- High voltage wire
- Electrical tape
- Cabinet
- Etc., etc., etc.



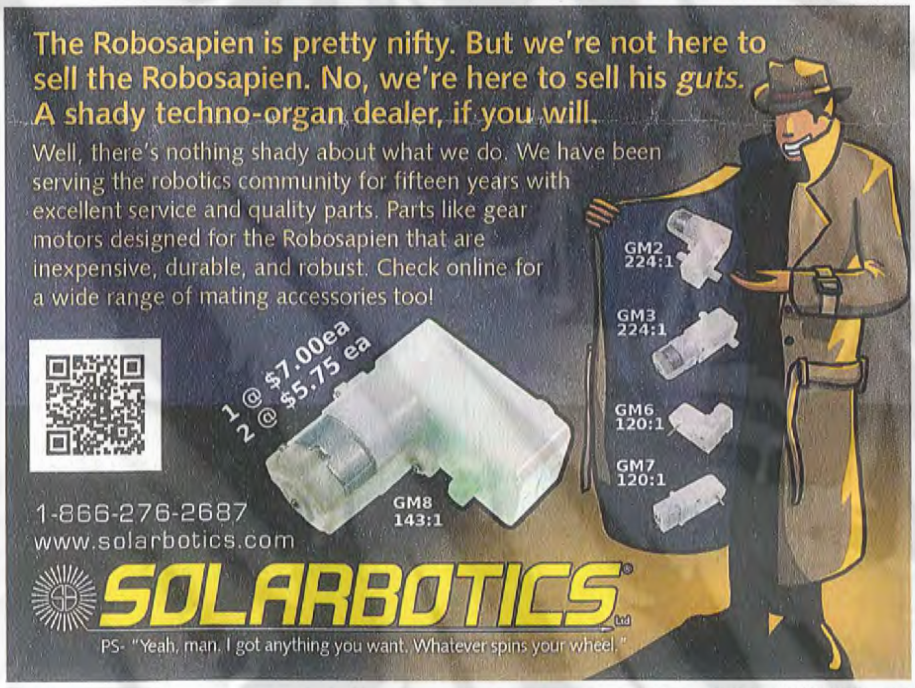


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MR. JEFF BEHARY
TURN OF THE CENTURY ELECTROTHERAPY MUSEUM
627 36TH ST.
WEST PALM BEACH, FL 33407

33407+4303

Инж. СЛАВКО БОКШАН

Can you read Serbian
or whatever language
this is?

I Jay



ПОКЛОН
СВЕСЛОВЕНСКЕ КЊИЖАРНИЦЕ
Београд - Поенкареова ул. 36
ЗА НАГРАДУ УЧЕНИКА

ИЗДАЊЕ
Свесловенске Књижарнице М. Ј. Стефановића и Друга
Београд, — Поенкареова 36.
1930.

Инж. СЛАВКО БОКШАН

НИКОЛА ТЕСЛА

И ЊЕГОВ ПИОНИРСКИ РАД У ЕЛЕКТРОТЕХНИЦИ

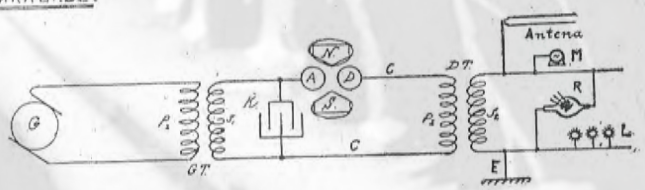


ПОКЛОН
СВЕСЛОВЕНСКЕ КЊИЖАРНИЦЕ
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ИЗДАЊЕ
Свесловенске Књижарнице М. Ј. Стефановића и Друга
Београд, — Поенкареова 36.
1930.

начава динамомашину наизменичне струје из које се шаље струја у трансформатор GT. Ако је динамомашина једносмислене струје онда трансформатор GT отпада. Високофреквентне струје стварају се у кругу КАОСР$_2$К. Брзина и јачина осцилације зависи од отпора, самоиндукције и капацитета струјних кругова. Отпор спроводника отежава кретање електричне струје, те је потребно узети што краће и што дебље спроводнике, да би се отпор смањио и омогућиле слободне осцилације. Кад се у струјном кругу, у коме се налазе кондензатор К, варница AD,

СЛИКА БР. 22.



Слика 22.

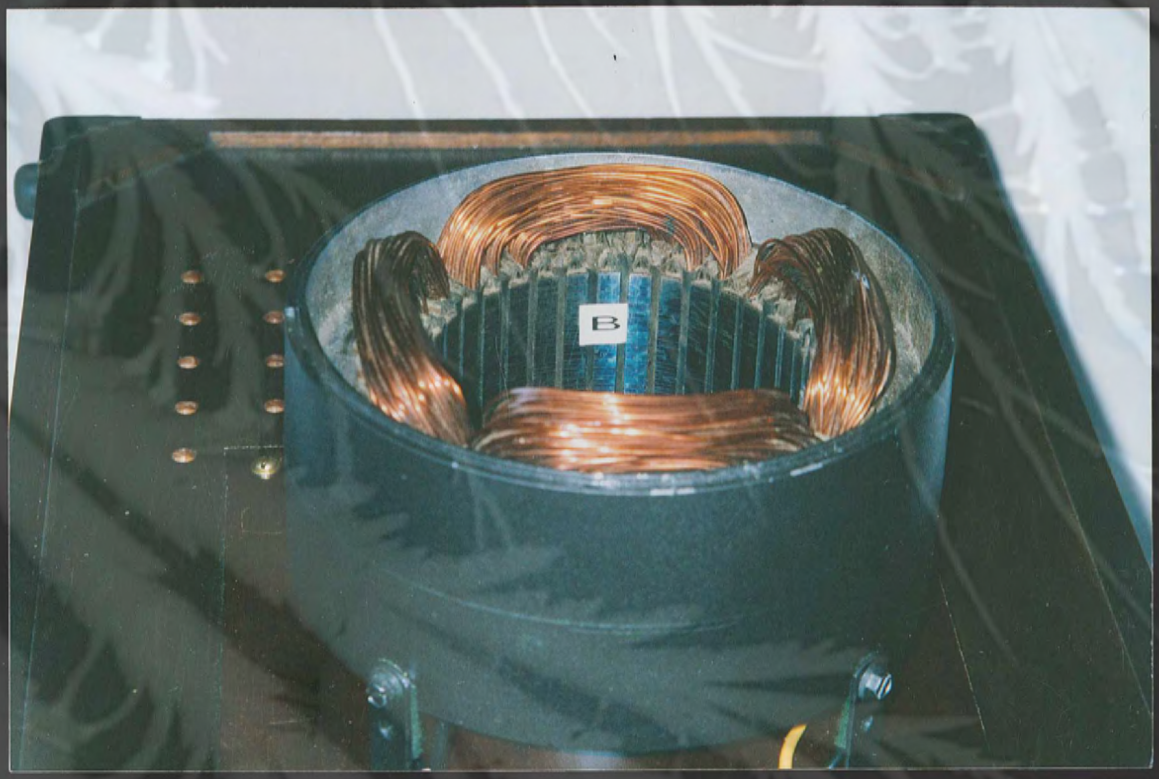
спроводник C и калем P_2, појави варница онда ће настати брзо осцилирање струје само у том случају, ако је целокупан отпор незнатан. Овај отпор је двојак, он зависи од ваздушног отпора између варничних кугала AD и од омског отпора спроводника и сијалица. Како је главни отпор ваздушан, то је потребно да је отстојање између кугала AD што мање. И у ваздушном и у омском отпору спроводника производи струја загревање и енергија се губи у форми топлотне енергије. Самоиндукција делује у овом погледу супротно. Да би осцилације биле што јаче, да би што дуже трајале и спорије се гушиле потребно је имати што већу самоиндукцију. Сваки

спроводник, кроз који прол
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поља, које изазива наизмен
цирају супротну струју и
осцилације, што код прави
приближно могућно. Сам
брзину осцилације, дакле
кунди, а исто то чини и капа
ставља извесну способност е
у себе електричну енергију
цијални апарати који служе
милава електрична енергија
ници имају известан капаци
него код кондензатора. И
затора мањи то ће мање вр
дензатор напуни и испра
електрицитета и према т
брже. Исто тако што је м
ног круга, требаће мање
нетског поља и осцилација
дакле добили што већи бр
кунду потребно је имати
мању самоиндукцију у с
ђутим кондензатор служи
то његов капацитет зависи
струје, коју желимо добит

Проблем производења
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енергије, да би струје
остварити врло велике фр
гушене осцилације изиск

I would be interesting
to date this schematic.
wireless
mechanical power
x-ray




B

A FRACTIONAL A.C. INDUCTION MOTOR
MINUS THE ROTOR ASSEMBLY.

ECKERD5788<No.
913 91** N N

G Harry Goldman
3 Amy Ln
Queensbury, NY 12804

12 November 2003

2809 NE 15th Street
Pompano Beach, FL 33062

Tesla Memorial Society, Inc.
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076

Dear Mr. Terbo,

It was indeed a great honour to meet you at the Tesla Energy and Electrotherapy Conference. An even greater honour was to find that you would take even a small interest in my work – in retrospect, for me this alone measures the entire success of my contributions to the event.

My research into the patents and ideas of Nikola Tesla began nearly a decade ago, upon my first acquisition of an early Electrotherapeutic Tesla Coil. That point forged the beginning of what is now called "The Turn Of The Century Electrotherapy Museum".

Simultaneously to acquiring the pieces of this collection, I began extensively (and exclusively) to make reproductions of the various apparatus which I had acquired. These reproductions proved two-fold: First, to obtain rare first-hand experience of the manufacturing technologies which were available in Tesla's lifetime, and second to experience first-hand the effects and knowledge of operating such obscure apparatus. These efforts (which I have spent thousands of hours, often days on end to accomplish) have proven themselves to be some of the fondest memories of my life. I can say with confidence that the vibrancy and often unbelievable imagery spoken in Tesla's lectures are in reality not only as spectacular as his words, but provides one with such an incredible sense of awe that only by experiencing these phenomenon in person can one begin to truly understand the man and his efforts.

I hope that from this point on I can share some of these experiences with you, and that through them you will perhaps gain some further insight into the experiences of your Grand Uncle. This is something that I certainly aspire to continue, for what can be more exciting than to try and see through the eyes of a man who changed the face of the entire planet?

Enclosed are a few examples that I hope you will find useful. The CD-ROMs contain the real bulk of information, but I have included some other items of interest that are more easily handled. I also have a vast collection of books and materials not included, which I hope to compile for you in the weeks that follow.

Respectfully yours,

Jeff Behary, c/o
The Turn Of The Century Electrotherapy Museum
Enclosures

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076
November 19, 2003

Mr. Jeffrey Behary
The Turn Of The Century Electrotherapy Museum
2809 NE 15th Street
Pompano Beach, FL 33062

Dear Mr. Behary:

Before I thank you for the fascinating collection of material from and about your museum that arrived this past Saturday, the 15th, I want to pay special attention to your cover letter that accompanied the package.

I've received many messages of appreciation for my efforts in bringing the personality and accomplishments of Nikola Tesla to a wider audience. But it is rare that I receive a letter such as yours that describes the connection that joins you to Nikola Tesla with such sincerity and heartfelt warmth. It makes my efforts worthwhile. Thank you.

It will take me some time to digest all the material you sent. My interest in your work is sincere. Your approach to this area of Tesla-type medical applications is different in that you concentrate on the equipment rather than the claimed efficacy of treatment. It is what drew me to your presentation. Previously, the rampant quackery of medical practitioners of Tesla's time obscured the several areas of true benefit. This put me off and left a gap in my knowledge in an area that I may now develop, thanks to your gifts. Whenever I use any of your material, I will credit the source.

I'm enclosing a number of Tesla and Society items I hope you will find interesting and useful for your museum. I look forward to a continuing exchange of ideas. Please feel free to contact me at any time. Thanks again.

Very truly yours,

William H. Terbo

WHT/tmsri

enclosures

The Tesla Memorial Society, Inc. *is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla. The Society supports various cultural activities, participates in appropriate academic conferences and provides a source for an accurate representation of Nikola Tesla for the media. The Society is a non-political, non-profit, all volunteer membership organization founded in 1979, incorporated in 1980, operating under Section 501 (c) (3) of the U.S. Internal Revenue Code.*

Visit our website: *teslamemorialsociety.org*

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076
April 2005

The Society has an extraordinary and beneficial relationship with The Turn Of The Century Electrotherapy Museum and its founder, Mr. Jeff Behary. The fruits of this relationship are the exchange of archival material from each organization as well as the sharing of new research and the publicizing of new work. I take this opportunity to distribute some of the archival material Mr. Behary (Jeff) has provided to the Society for Members and others who are fascinated by the technological vision of Nikola Tesla.

The current item for distribution is the article by Thomas Commerford Martin *TESLA'S OSCILLATOR AND OTHER INVENTIONS, An Authoritative Account Of Some Of His Recent Electrical Work* as published in the April 1895 issue of The Century Magazine (Vol. XLIX, No. 6, pages 916-933). The article is nearly 9,000 words in length and includes 14 excellent, historic photographs and one early Tesla oscillator diagram. Immediately following Martin's article is a short poem *IN TESLA'S LABORATORY* by Robert Underwood Johnson.

Jeff has provided the Society with a very high quality color copy of the article directly from his own original copy of the Century Magazine issue. The copy being distributed is a high quality Xerox directly from the original. The advantages of this reproduction over other published works are the exceptional clarity of the photos and the sense of handling the original document in its published form. (I have chosen to distribute the document printed on both sides of each page as is the original and for postage economy.)

The Turn Of The Century Electrotherapy Museum (2809 NE 15th Street, Pompano Beach, Florida 33062) collection includes a great number of original electrotherapy machines, components and equipment and reproductions built by Jeff to Tesla specifications and to manufacturing technologies available a hundred years ago. Jeff's approach to Tesla-type medical applications is his concentration on the equipment rather than the claimed efficacy of treatment. Previously, the rampant quackery of medical practitioners of Tesla's time obscured the several areas of true benefit.

I invite everyone to access the Electrotherapy Museum's online 1,000 Megabyte site of over 30,000 files (www.electrotherapymuseum.com). Jeff also offers an offline Museum of seven or more CD-ROMs.

William H. Terbo, Executive Secretary TMSuz

The Tesla Memorial Society, Inc. *is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla. The Society supports various cultural activities, participates in appropriate academic conferences and provides a source for an accurate representation of Nikola Tesla for the media. The Society is a non-political, non-profit, all volunteer membership organization founded in 1979, incorporated in 1980, operating under Section 501 (c) (3) of the U.S. Internal Revenue Code.*

3/10/2005

From WILLIAM TERBO

DEAR JEFF:

JUST RECEIVED YOUR EXCELLENT PHOTO & XEROX PACKAGE. THANKS!

ABOUT THE 1ST EDITION OF TESLA'S LONDON (1892) LECTURE. I HAVE HIS 1893 LECTURE ON "LIGHT." (SEE PAGE 4 OF MY EXPANDED "BOOKS" LISTING. I'VE XEROXED COVER & 2 INTERIOR PAGES FOR YOU. I'M WILLING TO XEROX THE ENTIRE BOOK - 115 PAGES - FOR YOU AND YOUR LONDON COLLEAGUE IF ASKED.) (THE ORIGINAL IS WELL USED AND HAS MANY PENCIL MARGINALIA BY MY DAD. XEROXING WON'T HURT IT.)

Item #PP142 The Drawing Board, Dallas, Texas 75206-0429
© Wheeler Group Inc., 1976

3/19 CONT'D

From WILLIAM TERBO

I DON'T REMEMBER IF I EVER SENT YOU A VHS VIDEO OF MY 90 MINUTE LECTURE TO THE ANTIQUE RADIO CLUB (IN 2000 OR SO). IF NOT, TELL ME AND I'LL SEND ONE.

I LOOK FORWARD TO YOUR NEXT PACKAGE. PARTICULAR THANKS TO THE 8X10 GLOSSY OF TESLA & MARK TWAIN IN THIS PACKAGE. I DIDN'T HAVE A GOOD COPY BEFORE.

BEST REGARDS TO YOU & RITA

P.S. I SEE YOU'VE SCHEDULED TO SPEAK IN SALT LAKE CITY IN JULY.

Item #PP145 The Drawing Board, Dallas, Texas
© Wheeler Group Inc., 1976



10/18/04

From WILLIAM TERBO

DEAR JEFF:

CONGRATULATIONS. SORRY WE CAN'T BE THERE IN PERSON.

TO MAKE UP FOR IT IN SOME SMALL WAY, I'VE ENCLOSED TWO BOOKS FOR YOUR COLLECTION. - PLUS A PHOTO OF YOURS TRULY WITH THE IVAN MESTROVIĆ BUST OF TESLA AT THE MUSEUM

CONGRATULATIONS AGAIN

William

Item #PP145 The Drawing Board, Dallas, Texas 75266-0429
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From WILLIAM TERBO 2/28/05

DEAR JEFF:

THANKS FOR THE CALL AND NEWS. I LOOK FORWARD TO A COPY OF THE 1893 CENTURY MAGAZINE TESLA ARTICLE. (AND ANYTHING ELSE OF INTEREST).

I'LL SEND YOU SOME BACKGROUND MATERIAL ON THE 1893 TESLA LETTERS WHEN I COMPLETE IT.

BEST REGARDS

William

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© Wheeler Group Inc., 1976

William & Boyana Terbo
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076-3136



JEFF & RITA BEITARY

7809 NE 15TH STREET

POMPANO BEACH, FL 33062

33062+3600 30

3/3/04

From WILLIAM TERBO

DEAR JEFF

THANKS FOR ACCESS TO YOUR WEBSITE. ALSO THANKS, U ADVANCE FOR THE COPY OF THE MATT 18 OF BOOK.

ENCLOSED ARE A COUPLE OF TESLA LETTERS FROM A NEWLY DISCOVERED ARCHIVE.

DON'T TRY TOO HARD TO READ THEM - I'LL BE KEYING IN A TEXT OV MY COMPUTER SOON.

BEST REGARDS

BILL

Item #FP145 Text and Design
© Wheeler Group Inc., 1978

Hallmark

Winter's Thaw -- Canada Geese © Terry Isaac
Artwork Courtesy of Mill Pond Press

PX 136-9

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20 DECEMBER 2004

DEAR JEFF & RITA:

May the holidays bring you
quiet moments to enjoy.

WITH BEST REGARDS

William & Bojana Tubb.



A note from
William H. Terbo

12/25/03

JEFF:

THANKS AGAIN FOR YOUR MATERIAL.

I'LL KEEP YOU INFORMED AS I PROCEED WITH THE NEW ITEMS.

REGARDS

Wm

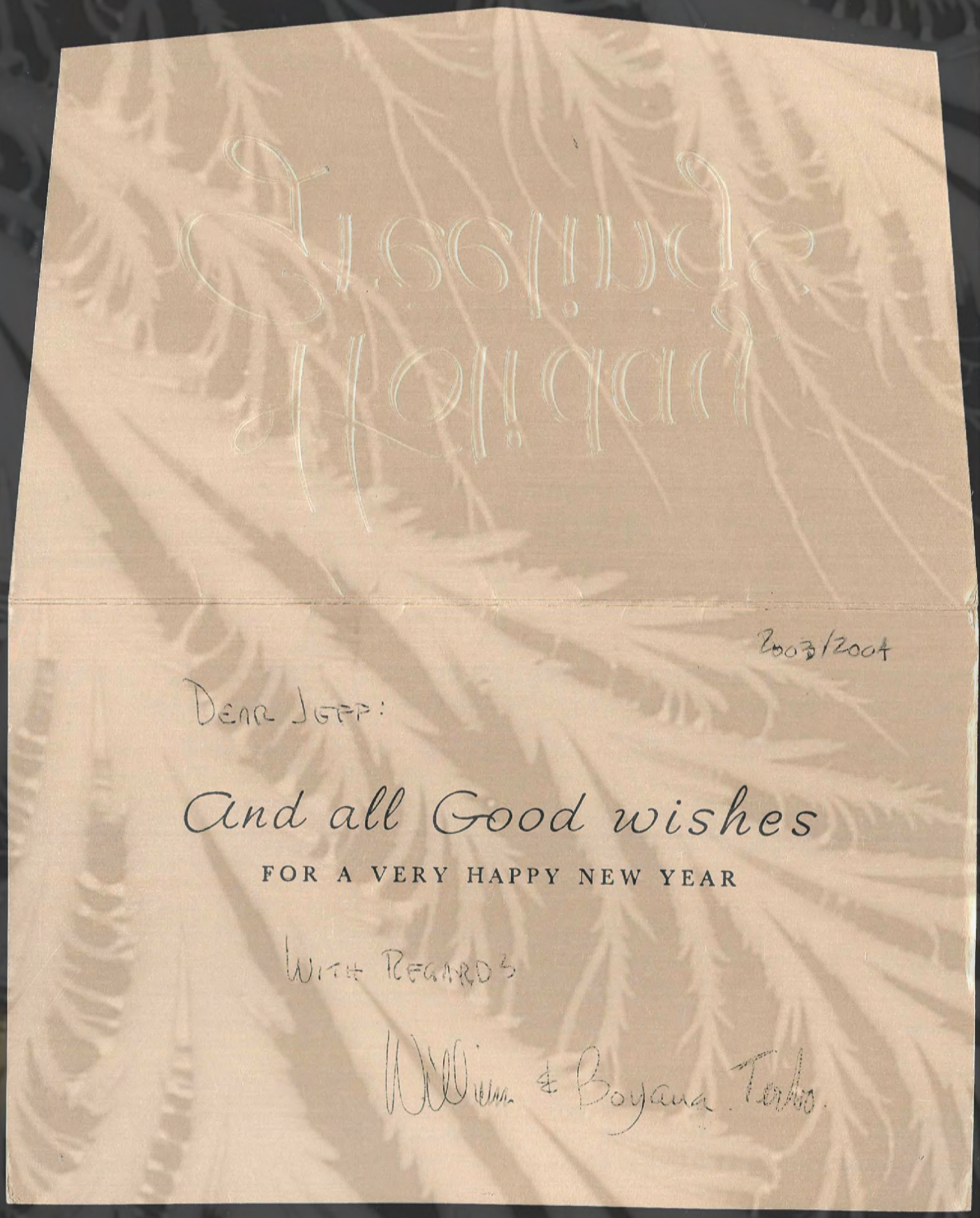
2003/2004

wishes

W YEAR

WITH REGARDS

Wm & Barbara Terbo



2003/2004

Dear Jeff:

And all Good wishes

FOR A VERY HAPPY NEW YEAR

With Regards

Wm. & Boyana Tasho.

Holiday Greetings

© MASTERPIECE STUDIOS, INC
CHICAGO ILLINOIS

December 25. 2006 And January 7. 2007

Dear Jeff and Rita

This says it all

perfect
LOVE
perfect
PEACE
perfect
JOY TO YOU.

Thanks for your
support and respect
Sincerely

Bill & Bojana

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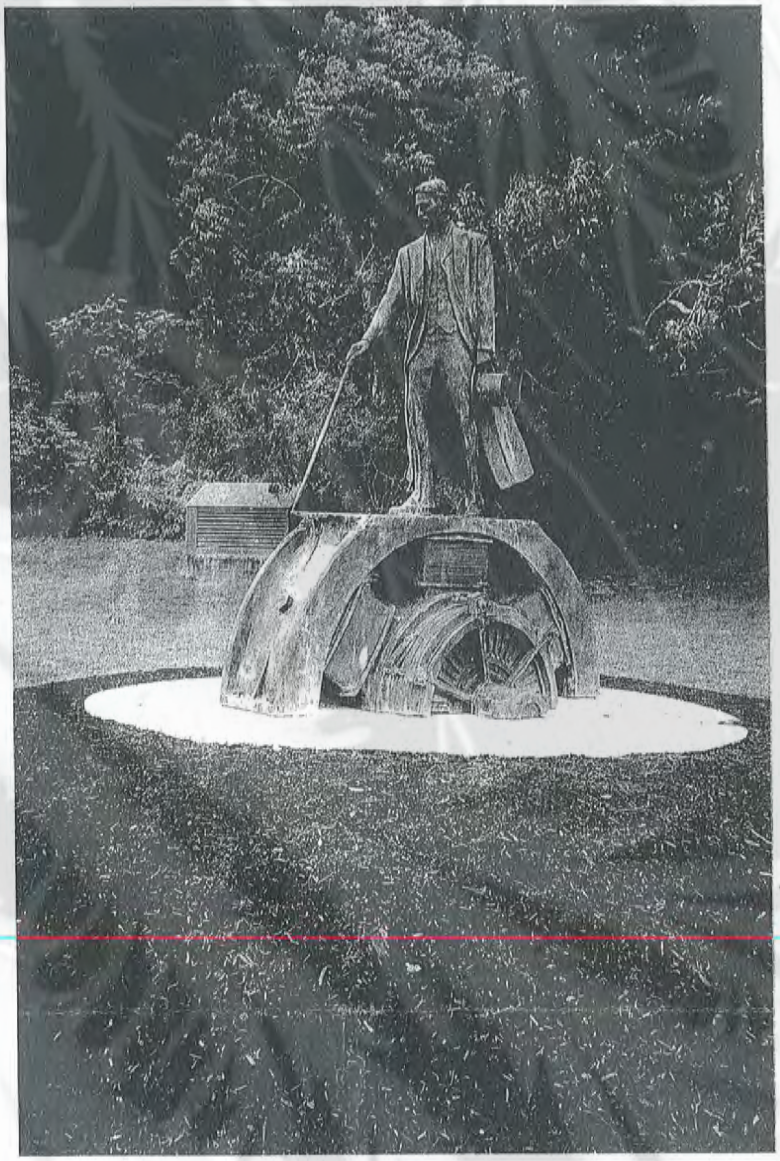
NIKOLE TESLE

1856 - 2006



Nikola Tesla

NEW STAMPS



NIAGARA FALLS
ONTARIO
7/10/06

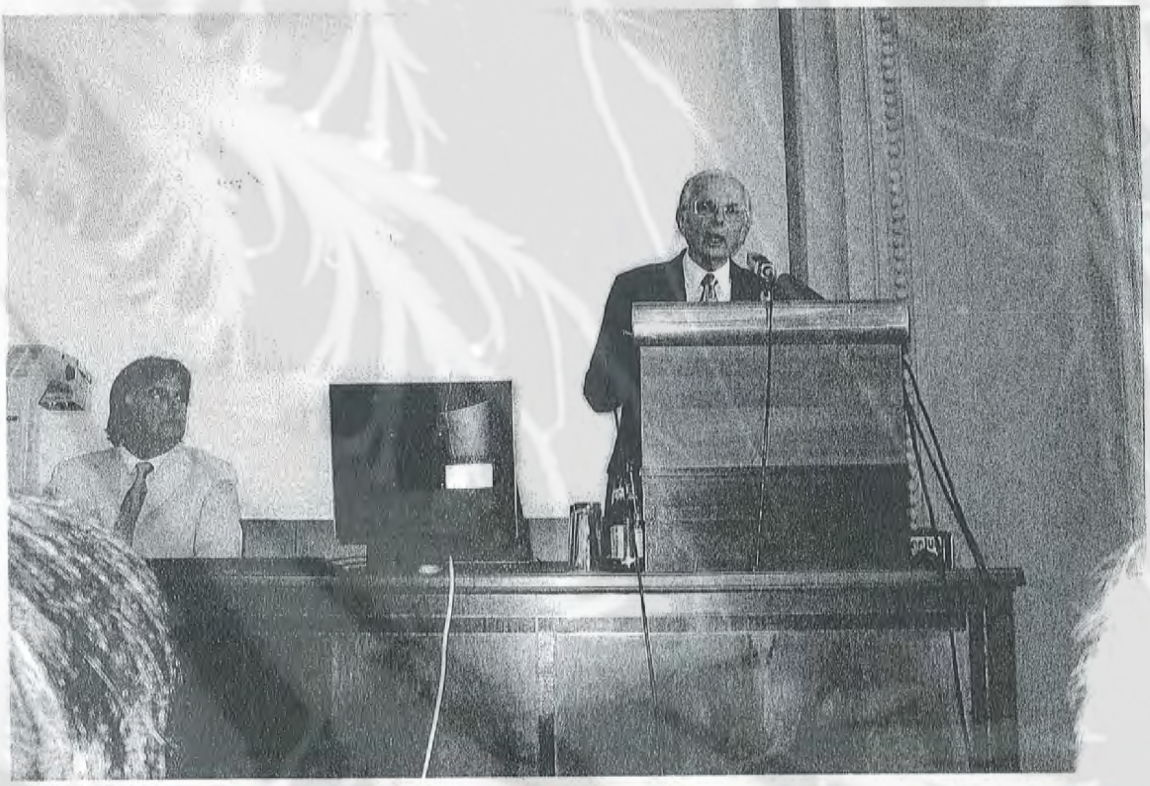




AT RECEPTION FOLLOWING CHURCH SERVICE : 800TH ANNIVERSARY MONASTERY ŽEČA 10/7/06



WITH SERBIAN MINISTER OF ENERGY (ELECTRICITY) AMONG OTHERS



KEYNOTE REMARKS
6TH TESLA SYMPOSIUM
SERBIAN ACADEMY OF SCIENCES AND ARTS
BELGRADE
10/18/06





INTERVIEW WITH DIRECTOR OF RUSSIAN TV 10/10/06 (WITH INTERPRETER)



WITH NEW DIRECTOR OF TESLA MUSEUM VLADIMIR JELENKOVIC

10/18/06



AT
NIKOLA
TESLA
INTERNATIONAL
AIRPORT
BELGRADE

"ROBOT"

LOSER



COMPARE

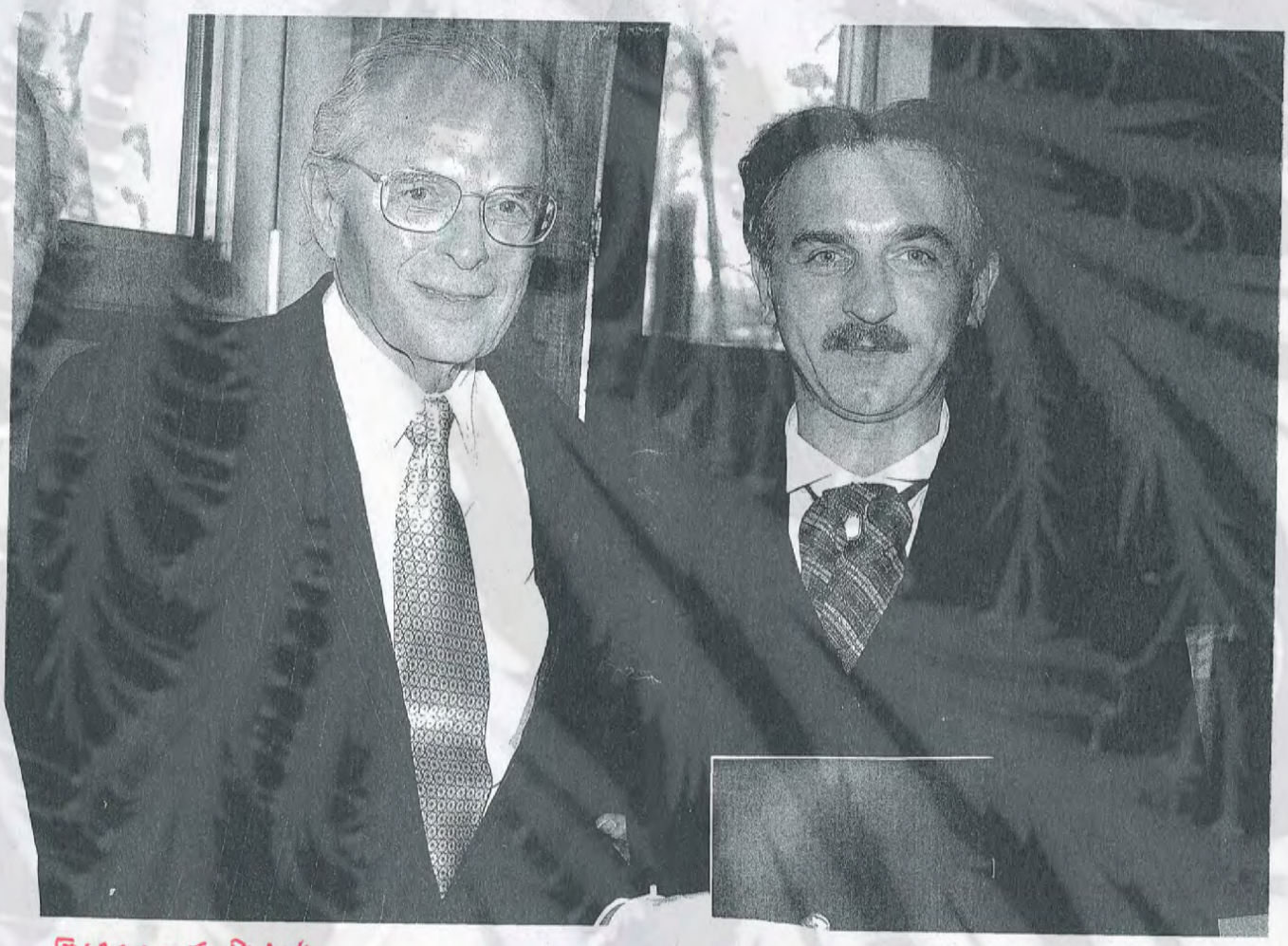
MY
ARRIVAL
10/3/06

AT
QUEEN VICTORIA PARK
OVERLOOKING
NIAGARA FALLS
ONTARIO

"DYNAMIC"

WINNER





EXCELLENT PLAY

WITH ACTOR "TESLA" 11/25/66



Вилијам Тербо испред портрета свог деде Николе Тесле

СНИМИО С. ЈОКАНОВИЋ

ВИЛИЈАМ ТЕРБО ЗА „ИЛУСТРОВАНУ ПОЛИТИКУ" (1)

Мој деда Никола Тесла

Срђан ЈОКАНОВИЋ

Ех, да је мали, несташни дечак Вилијам Тербо знао да ће му тих пола сата обележити цео живот, не би тако нестрпљиво чекао да његова мама Елис коначно заврши разговор са дедом Николом и да изјури из хотела „Њујоркер" у коме се сусрет дешавао. Мама је обећала да ће га тог дана одвести у нову музичку дворану у Њујорку, али се сетила да би успут могли да сврате и до „чика Николе".

„О не", помислио је мали Вилијам који је имао осам или девет година и најмање на свету су му били занимљиви разговори са одраслим рођацима, ма колико (поготово?) они паметни били.

- Истина је - прича нам господин Тербо уз осмех који подмлађује ионако младолико лице овог човека рођеног 1930. године у Детроиту. Он је данас најближи живи рођак Николе Тесле.

Славног научника, рођеног брата своје баке Ангелине, Вилијам је видео неколико пута. Ипак, био је сувише мали да би се сећао Теслиних посета њиховом дому у Детроиту.

- Долазио је најмање два пута али о томе знам више из прича мојих родитеља него из сопственог сећања. Знам да су га мама и тата једном водили на ручак у најбољи хотел у Детроиту. Чим су ушли, цело особље хотела се скупило око Николе и мог тате који је такође био познати научник. Желели су да им понуде најбољу услугу, најбоља јела, најбољи угођај. Оркестар је свирао у позадини, све је било гала а када је требало да наруче јело, Никола Тесла је затражио хлеб и млеко! И моје родитеље и послугу хотела је било срамота. Сви су хтели Теслу да опчине луксузом а он је узео најскромније могуће јело.

Зато се Вилијам Тербо много боље сећа оног сусрета у хотелу „Њујоркер".

- Нисам сигуран која је тачно била година, али знам да је било после оне не-

1ST PAGE OF 2-ISSUE ARTICLE IN ILLUSTRATED POLITIKA 11/11 & 18/06 (TOTAL 8 PGS.)

AT HOME IN KRALJEVO SERBIA WITH NEW GIFT PAINTING (ON PATIO) (PAINTING NOW IN HOME, SKETCH PAINTING)

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

NIKOLA TESLA MEMORIAL MONUMENT

DEDICATION AND UNVEILING, SUNDAY, JULY 9, 2006

QUEEN VICTORIA PARK, NIAGARA FALLS, ONTARIO

A dedication and unveiling ceremony was held on July 9th for the beautiful new bronze statue of Nikola Tesla. The statue is located in Queen Victoria Park directly overlooking Niagara Falls from the Canadian side. I was pleased to participate, as the closest living relative, to represent the Tesla family in the ceremony. I've enclosed some representative photos of the statue and its spectacular site plus other items to provide event details.

Radio Television Serbia provided a large production contingent for a 45-munite live satellite TV feed to Belgrade for prime-time broadcast as a part of their extensive Tesla 150th Anniversary Celebration. The German documentary maker, Maxim Films of Berlin, also covered the event as well as area media.

The event opened with a large chorus singing the Canadian and Serbian anthems followed by a program starting with short congratulatory remarks by representatives of the Canadian National and Provincial governments, the Serbian government, the Niagara Parks Commission and the Mayor of Niagara Falls. The statue was then unveiled with a traditional hymn by the chorus. The Chairman of the Tesla Memorial Statue Committee offered a few remarks and the program concluded with my short remarks linking the blood of Tesla with the statue.

The entire program is available on website *www.teslaevent.com*. I spoke for about three minutes extemporaneously and with feeling. I'll put remarks to paper when I receive my copy of the ceremony.

William H. Terbo
Executive Secretary

TMSzw

The Tesla Memorial Society, Inc. *is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla. The Society supports various cultural activities, participates in appropriate academic conferences and provides a source for an accurate representation of Nikola Tesla for the media. The Society is a non-political, non-profit, all volunteer membership organization founded in 1979, incorporated in 1980, operating under Section 501 (c) (3) of the U.S. Internal Revenue Code.*



DEDICATING REMARKS AT UNVEILING 7/9/06



THE REVIEW SATURDAY JULY 8, 2006
NIAGARA FALLS, ONTARIO, CANADA

A PLACE OF HONOUR FOR TESLA



Mike DiBattista, The Review

Artist Les Drysdale, of Hamilton, looks on as the monument he created of Nikola Tesla is ready to be lifted into place across from the Horseshoe Falls. The memorial to Tesla will be officially unveiled at noon Sunday.

Honouring Tesla's electric vision

Bronze statue erected near falls

BY COREY LAROCQUE
Review Staff Writer

NIAGARA FALLS – When Nikola Tesla was a young boy in Serbia, he envisioned drawing power from Niagara Falls. Now, the inventor of alternating current has a permanent tribute overlooking the Horseshoe Falls.

Members of St. George's Serbian Orthodox church have donated a bronze statue of Tesla, who has national hero status in his homeland. They wanted to create a lasting tribute on the 150th anniversary of Tesla's July 10 birth.

"He's someone the Serbian community feels has been, if not neglected, certainly overlooked throughout history," said Dushan Kolundzic, the president of St. George's church.

As a boy, Tesla saw a picture of the Horseshoe Falls in a travel book and told his uncle he wanted to put a wheel under the falls to harness the power of the moving water. The new statue stands at the same point where that photograph was taken.

"Having him here at the Falls is extremely important, because it captures the complete circle," Kolundzic said.

The 2,000-pound statue shows Tesla in a long overcoat, carrying a top hat in his left hand. In his right hand, he's carrying a cane, depicting the moment he conceived of alternating current by drawing diagrams on the ground.

He's standing atop an AC motor, one of the 700 inventions he patented. The motor is similar to the "Teslatron" statue in the Fallsview Casino's entrance, which also pays homage to the inventor.

Alternating current is the type of electricity used throughout the world because it can be transmitted over long distances.

The Tesla monument will cost about $165,000, but the total price tag could be $220,000 by the time the bills for a concrete foundation and landscaping come in, Kolundzic said.

It will be unveiled during a ceremony Sunday at noon, followed by a Serbian cultural program at 2 p.m. in Oakes Garden Theatre.

An international design competition led to more than 20 submissions, but the judging committee liked one that came from Hamilton artist Les Drysdale.

See STATUE on Page A2

STATUE: Another erected in Belgrade

Continued from Page A1

"The honour of being chosen to alter the landscape of the Niagara Parks is incredible. Who gets to do that?" said Drysdale.

Drysdale wore a T-shirt with Tesla's picture as "the man who powered the world," as he supervised the placement of the statue Friday morning.

The Niagara Parks Commission doesn't have many statues in Queen Victoria Park, but Tesla is a fitting addition, said Debbie Whitehouse, the executive director of parks.

"The history of Niagara Parks and hydro-electricity are entwined together. You see that everywhere you go in the Niagara Parks," she said.

Drysdale's statue captures Tesla's spirit, said Bill Auchterlonie, who led the church's statue committee.

The inventor often appeared in photographs looking "serious, as if he was day-dreaming, look in his eye," Auchterlonie said.

"He's got Tesla. You feel like your looking at Tesla. ... He may be standing on this generator. His mind is a million miles away," Auchterlonie said.

Celebrating Tesla's accomplishment is a big deal not just for Serbian-Canadians, but back in his native land as well. A news crew from Serbia's national broadcaster was in Niagara Falls filming the statue's installation and its unveiling. Belgrade's airport is being renamed in Tesla's honour and the statue that finished second place in St. George's competition is being erected at the airport.

clarocque@nfreview.com

PHOTOS TAKEN AT THE DEDICATION OF THE TESLA BUST

ST. SAVA CATHEDRAL, JANUARY 28, 2007

The bust of Nikola Tesla is in the background of the photos (in the Cathedral forecourt, behind the fence.)

See Dedication Report (**TMSam2**) for further identification details.

Identification of persons from left to right.

Photo #1:

Mirjana Sovilj, William Terbo, Maria Wera Cedrell, Svetlana Djokovic

Photo #2:

Marina Zivic (sculptor), William Terbo, Mirjana Sovilj, Svetlana Djokovic, Maria Wera Cedrell

Photo #3:

William Terbo

TMSas2

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Statement by William Terbo at Dedication of Bust of Nikola Tesla, January 28, 2007

To:

Princess Elizabeth Karageorgevic
Ms. Mirjana Sovilj, PhD
Ms. Maria Wera Cedrell, Esq.
Ms. Svetlana Djokovic

Dear Donors:

Speaking for the family of Nikola Tesla and for the Society that honors his name, I wish to commemorate the dedication of your gift of the bust of Nikola Tesla to St. Sava Cathedral. I am gratified that you have thought to honor the man for whom I have labored for the past thirty-odd years to restore his name to his proper place in world technological and social history. Your generosity is very much appreciated.

I also wish to reflect on the artistic skill that sculptress Marina Zivic has exhibited in transforming her genuine respect and love for Nikola Tesla into her creation of this work of art.

I want to thank Cathedral Dean Very Reverend Father Djokan Majstorovic for his dignified dedication program. And to thank the Cathedral congregation for their support that brought event into being.

Your bust of Nikola Tesla is now established in a proper and publicly accessible place in the City where he lived and worked.

You may take great satisfaction in providing an excellent example of an American of Serbian ethnicity who demonstrated world leadership in the current context of world difficulties for Serbs.

My most sincere congratulations to you all.

TMSav

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Visit our website: *teslamemorialsociety.org*

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

BUST OF NIKOLA TESLA DEDICATED AT ST. SAVA CATHEDRAL

A bronze bust of Nikola Tesla was dedicated in the forecourt of Manhattan's St. Sava Serbian Orthodox Cathedral, 13-15 West 25th Street, on Sunday, January 28, 2007. The bust was donated by an international group of four individuals with Serbian ethnic ties and an appreciation for the personality and accomplishments of the great American inventor of Serbian ethnicity, Nikola Tesla, Father of Alternating Current and foremost contributor to the technology of modern radio.

The bust is mounted on a five-foot black marble pedestal. The image depicts Tesla in his late 50's, hair parted in the center and looking slightly to his left showing both face and profile. His shoulders are visible revealing the cut of his dinner jacket, wing-tip collar and full tie, the formal manner of dress for which he was so famous. Sculptor, Ms. Marina Zivic of Belgrade, created the bust in her studio and had it cast in Serbia

The 150th Anniversary of the birth of Nikola Tesla, 2006, has been celebrated throughout the world with special emphasis in Serbia where 150 events were organized to commemorate his Serbian ethnicity. Delivery of this bust is a part of that yearlong recognition of the great scientist. Nikola Tesla lived the greatest part of his life in Manhattan and created the bulk of his legacy in Manhattan. The bust represents the first image of Tesla in Manhattan that can be viewed from a place accessible to the general public.

January 27 is a particularly important date on the Serbian Orthodox calendar. St. Sava is the leading Serbian Orthodox Saint and the name-patron of the Cathedral. The Services of the 28th specifically honored St. Sava. The Tesla bust dedication ceremony was conducted immediately following the Cathedral services.

Cathedral Dean, the Very Reverend Father Djokan Majstorovic, opened the ceremony performing the blessing of the bust. Short remarks were made by donators Ms. Mirjana Sovilj, PhD, Director of The Institute for Experimental Phonetics and Speech Pathology, Belgrade; Ms. Maria Wera Cedrell, Attorney and Producer for World Television Network, Stockholm; and, Ms. Svetlana Djokovic, General Manager of Academy of Arts "BK", Belgrade. (Princess Elizabeth Karageorgevic, President, Princess Elizabeth Foundation, New York, was traveling and unable to attend.) Bust sculptor, Ms. Marina Zivic, was introduced and the ceremony concluded with remarks by Church President, Mr. Nenad Milinkovic. Among those attending the ceremony was Mr. William H. Terbo, closest living relative of Nikola Tesla.

The Tesla Memorial Society, Inc. *is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla. The Society supports various cultural activities, participates in appropriate academic conferences and provides a source for an accurate representation of Nikola Tesla for the media. The Society is a non-political, non-profit, all volunteer membership organization founded in 1979, incorporated in 1980, operating under Section 501 (c) (3) of the U.S. Internal Revenue Code.*

Nikola Tesla (1856-1943) was born in the Military Frontier Province of Austria to a Serbian Orthodox priest, Rev. Milutin Tesla, and his wife, Djuka. His birthplace later became part of Yugoslavia and is now in the Republic of Croatia. Technically educated and showing great promise in his early professional career, Tesla came to America in 1884 where he soon filed the basic patents that describe the entire system of AC power generation, transmission and utilization. The AC electrification of Niagara Falls in 1896 (with George Westinghouse) is one of his most notable accomplishments. By 1900 Nikola Tesla was one of the world's most famous personalities. He was granted over 200 U.S. patents (and more than 200 foreign patents) that covered the basics of radio, robotics, high-frequency electronics and basic contributions to computer technology.

St. Sava Cathedral, a Manhattan institution, has had a continuous relationship with Nikola Tesla and recognizes his date of birth each July. The Cathedral was built in 1855 as the Chapel of the famous Trinity Episcopal Church in lower Manhattan. It was deeded to the Serbian Orthodox congregation in early 1943. Tesla passed on January 7th, 1943, ironically, Christmas on the Christian Orthodox calendar, and is registered as the fifth entry on the St. Sava Cathedral Record of Deaths.

Tesla was accorded a State Funeral at Manhattan's Episcopal Cathedral of St. John the Devine on January 12th. St. John the Devine at West 112th Street, the largest Gothic cathedral in the world, accommodated the more than 2,000 who attended. The funeral service opened with Episcopal Bishop William T. Manning and concluded with St. Sava Cathedral priest, Prota Dusan J. Sukletovic (Very Reverend Dushan J. Shukletovich.)

The 50th Anniversary of Nikola Tesla's passing was held at St. Sava Cathedral on January 16, 1993. The Church ceremony included the full Orthodox Requiem with eulogies by four area Serbian Orthodox priests. The Tesla Memorial Society, Inc. sponsored the Church ceremony and following reception with donations defraying all expenses.

A matching black marble pedestal (also designed by congregation member, Mr. Branko Zec) has been erected in the Cathedral forecourt a few feet from the Tesla pedestal. The bust of Michael Pupin (1854-1935) is to be placed there to honor the second great American scientist of Serbian ethnicity. Pupin was the inventor of the Telephone Induction Coil that enabled long distance telephony and the founder of the Columbia University School of Electrical Engineering. The Pupin bust is currently located in a niche in the side of the Cathedral facing the church rectory. The considerable extra cost of the construction and dedication of the two bust presentations is to be met through an appeal for private contributions.

William H. Terbo, Executive Secretary TMSam2

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Visit our website: *teslamemorialsociety.org*

As he admired the Budapest sunset, TESLA ENVISIONED the solution to his motor problem.



TWO-PHASE alternating-current (AC) induction motor was built by Tesla in 1887. By energizing pairs of induction coils on either side of the stator with two separate out-of-phase alternating currents, he created a rotating magnetic field that induced an opposing electric field in the rotor, causing it to turn.

val ship. Here, more than a century ago, was a prototype for the guided missile.

Despite this spectacular demonstration, Tesla never converted his remote-control boat into a full-fledged weapon. His failure to do so is emblematic of a larger theme that permeated his life—a profound idealism that only occasionally reached practical reality. Throughout his career, Tesla strove to find the perfect principle on which to base a revolutionary invention. Having identified a grand concept, he was willing to patent and demonstrate it, but he often left it to others to carry out the down-and-dirty work of engineering a moneymaking product. Sadly, as his career progressed, the famous inventor found it increasingly difficult to convince prospective backers to help with the messy process of commercialization. As a result, he grew ever more disappointed with and disconnected from the world.

Overview/*Nikola Tesla*

- **Nikola Tesla (1856–1943) was a Serbian-American inventor and researcher who discovered the rotating magnetic field, the basis of most alternating-current (AC) machinery—dynamos, transformers and motors. He also invented the Tesla coil, a high-voltage induction coil used widely in radios, televisions and other electronic equipment.**
- **Tesla was a great showman and a favorite of newspaper reporters who sought sensational copy. His outrageous claims that he communicated with other planets and had developed a death ray led to considerable criticism, however.**
- **Despite devising many important fundamental technical concepts, Tesla rarely bothered to engineer them into usable products. Sadly, he was impractical about financial matters and ended up dying in poverty and obscurity.**

Motor Visionary

TESLA WAS BORN on July 10, 1856, to a Serbian family living on the frontier of the Austro-Hungarian Empire, in what is today Croatia. As a teenager, Tesla chose to study engineering at the Joanneum Polytechnic School in Graz, Austria. There the youthful scholar eagerly attended the physics lectures presented by Jacob Poeschl in 1876 and 1877.

During Poeschl's lectures, Tesla first started thinking about what would become his most important invention, an improved AC motor. One day he watched his professor attempt to control the troublesome sparking of a direct-current (DC) motor's brush commutator—copper-wire electrical contacts that reverse the current twice during each rotation so that the resulting opposing magnetic fields keep the rotor turning. Tesla suggested that it might be possible to design a motor without a commutator. Annoyed by the student's impudence, Poeschl lectured on the impossibility of creating such a motor, concluding: "Mr. Tesla may accomplish great things, but he certainly never will do this." The rebuke, however, merely stoked the fires of the youth's ambition. Tesla puzzled incessantly about how to make a spark-free motor as he pursued his studies in Graz and then in Prague.

In 1881 Tesla traveled to Budapest, hoping to work for family friends, Tivadar and Ferenc Puskas. An ambitious promoter, Tivadar had previously convinced Thomas A. Edison to give him the commercial rights to introduce inventions developed by the Wizard of Menlo Park in continental Europe. The Puskas brothers were planning to construct a telephone exchange in Budapest using Edison's improved telephone design. Unfortunately, they were unable to hire anyone immediately. While waiting, Tesla fell seriously ill. He only recovered with the help of a college friend, Anthony Szigeti, who encouraged the sick man to walk each evening to help regain his strength.

It was during one of these strolls with Szigeti that Tesla had an epiphany about motors. As they admired the sunset, Tesla suddenly envisioned using a rotating

SCIENCE MUSEUM/SCIENCE AND SOCIETY PICTURE LIBRARY

From WILLIAM TERBO 2/28/07

DEAR JEFF & RITA:

NEW ITEMS.

YOU CAN PUT ANY OF ALL OF IT ON YOUR WEB SITE.

ALSO. I'LL SEND THE TAPE TO YOUR COLLEAGUE OUT WEST AS SOON AS I SEE DAYLIGHT. (I SPOKE TO HIM BY PHONE.)

BEST REGARDS

Bill & Barbara

Item #PP145 The Drawing Board, Dallas, Texas 75266-0429
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William & Boyana Terbo
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076-3136
DVD P&DC NJ 073
PM
JAN23
2007
3c USA
USA
84
JEFF AND RITA BEHARY
627 36TH STREET
WEST PALM BEACH, FL 33407

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

MICHAEL IDVORSKY PUPIN – 150TH ANNIVERSARY OF HIS BIRTH

The Tesla Memorial Society, Inc., its Executive Board and members join with all people who value the scientific and technological advances that have created the modern society in which we live in honoring the birth of Michael Pupin.

Michael Pupin, inventor, humanitarian and philosopher, is best known in the scientific community as the inventor of the Telephone Induction Coil (1899) a device that in one single step made long distance telephony possible. Sold in 1901 to the Bell System for an unprecedented sum that gave him the opportunity expand his vision beyond the field of his choosing. Also among Dr. Pupin's 34 U.S. patents were important radio developments and seminal work in Short Exposure X-Ray technology (1900) that led to the safe use of the new x-ray technology in medical diagnostics.

Michael Pupin was born on October 4, 1854 in the small village of Idvor in what is now a part of Serbia. He came to America at the age of 16 with only five cents in his pocket but with boundless energy. Within five years he had prepared himself for entry into Columbia College (University), graduated with honors, continued at Cambridge in England and received his Doctorate in Physics in Germany. He returned to a teaching position at Columbia where he soon founded the School of Electrical Engineering. Dr. Pupin remained associated with Columbia for the rest of his life. Shortly after his death on March 12, 1935 Columbia renamed the Physics building *Pupin Physics Laboratories*.

Dr. Pupin's Peace Conference advice to President Wilson was instrumental in resolving the borders that would define the new country that was to become Yugoslavia. Dr. Pupin served as the President of several important professional institutions including the New York Academy of Sciences, the American Institute of Electrical Engineers and the Radio Institute of America. Among his many honors was the Edison Medal (1920). Michael Pupin wrote three well-received books including the best selling autobiography of his fascinating life *From Immigrant To Inventor*, awarded the Pulitzer Prize in 1924.

On a personal note I wish to privately honor Michael Pupin on this significant year. Dr. Pupin was a personal friend and mentor of my father Nikola J. Trbojevich (Terbo) from the very time of father's arrival in America. It has been my privilege to honor Dr. Pupin several times in the past. I've attached a brief summary of that special connection.

William H. Terbo, Executive Secretary
(732) 396-8852

TMSsw2

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TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076
25 June 2004

Mme Marija Sesic, Director
Nikola Tesla Museum
Krunska 51
11000 Belgrade
Serbia and Montenegro

Dear Mme Sesic:

Mr. Mrkich informs me that you have resumed your duties as Director and that your health has improved somewhat. I pray for continued improvement for your personal well-being and so that you can return to 100% efficiency.

My travel plans for Serbia are confirmed. I will arrive on September 12 and return on October 2. I plan to spend at least several days in Belgrade within that period. I will contact you beforehand to set up convenient time(s) for Museum visits. I have a Tesla correspondence research project that you will find interesting and with which you or your staff will be able to help.

I have access to a "lost" archive of personal correspondence from Tesla to Edward Dean Adams, the Managing Director of the Niagara Falls project. The earliest letter is dated January 7, 1893 and is written by hand on stationary of the Gerlach Hotel. It addresses the earliest attempts at commenting on the Niagara project specification. Later letters are dated February 2, February 6, March 12, March 21, March 22, March 26, May 11, July 27 and September 6, 1893. It appears that during this period the choice of the system for Niagara was still up in the air. There are later letters, as well, which indicate a relatively close working and personal relationship between the two.

What I will need to complete an analysis of this interesting phase in a project that changed the world is: (1) Xerox copies of letters, notes or messages from Adams to Tesla during this period; (2) Tesla's drafts of the letters actually sent to Adams; and (3) any type of correspondence between Tesla and Westinghouse during this period (to see if Tesla was acting completely alone or in concert with Westinghouse and/or Westinghouse engineers). I trust that you and your staff can accommodate. Of course, anything I create will be properly credited and available to the Museum.

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Visit our website: *teslamemorialsociety.org*

On a personal note and as a special favor, I would like neat Xerox copies of all the correspondence from my father to Tesla. Unlike Tesla, my father did not keep his drafts.

I look forward to our September meetings. Best regards to you and yours.

COPY (FYI ONLY)

William H. Terbo
Executive Secretary

WHT/tmsss

The Tesla Memorial Society, Inc. *is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla. The Society supports various cultural activities, participates in appropriate academic conferences and provides a source for an accurate representation of Nikola Tesla for the media. The Society is a non-political, non-profit, all volunteer membership organization founded in 1979, incorporated in 1980, operating under Section 501 (c) (3) of the U.S. Internal Revenue Code.*

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Radio Prague - the international service of Czech Radio

Dan Malvik June 16, '04

A daily in-depth look at current events in the Czech Republic.

Czech radio became part of Tesla Planetary Gathering

[11-07-2003] By Mirna Solic

Listen 16kb/s ~ 32kb/s

On Thursday Czech Radio became part of the international multimedia project Tesla Planetary Gathering. The project was initiated by Serbian Radio Belgrade, and it aims to create a network of radio stations connecting the towns where Nikola Tesla lived and worked. A newly-installed bust of Tesla, unveiled yesterday in the Czech Radio building, is a memorial to the scientist who established the basic concept of radio technology, a genius who spent a significant part of his scientific and intellectual life at the Technical University in Prague. Mirna Solic reports:



A newly-installed bust of Tesla

Nikola Tesla was born in 1856 into a family of Serb peasants in one of the poorest regions in Croatia, which was then part of the Austro-Hungarian Empire. Before leaving for America to begin the period of his great research, Tesla was heavily involved in the intellectual life of Central Europe. The inventor of radio technology, rotating magnetic fields and polyphase AC currents studied at the Technical University in Prague, which was at that time one of the best technical schools in Europe. He was ingenious but his work wouldn't be possible without the knowledge of philosophy and physics he gained in Central Europe, says Drenka Dobrosavljevic from Radio Novi Sad:

"At that time Ernst Mach, one of the greatest European philosophers and physicist, was teaching in Prague. At that time there were also professors in Graz and Prague who had a deep knowledge leading to the invention of telegraphy. That points to

JUN-23-2004 10:45 CANADIAN CONSULATE 7158524340 P.04/04
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ume at Tuesday's invitation-only "This is far better than anybody I have imagined."

has been nine years since the ncial government announced Ni- Falls would host a permanent nercial casino. After 2½ years of ruction, Falls Management Co., onsortium that built the casino, ed the doors for the first time.

you, I say you've made our ns come true," said Liberal MPP raitor.

ing the opening ceremonies, ps recalled the long road begin- with the 1994 referendum when nts said they wanted a casino to enerate jobs.

hat time, casinos have become an tant part of the local economy invaluable source of revenue for ovincial government, which owns tario casinos.

benefits felt throughout our city ting Casino Niagara have been ndous," said Mayor Ted Salci. "I the benefits from this new facili- exceed all of our expectations."

I commended the efforts of for- layor Wayne Thomson and for- IPPs Bart Maves and Marg Hae- n for opening the door to casinos ario and in Niagara Falls.

ario is expected to take in $2.1 billion from gambling this year.



The Niagara Fallsview Casino Resort was opened at an invitation-only gala Tuesday. Below: A dealer waits for players after the official opening of the casino.

STAFF PHOTO BY DENIS CAHILL



The Fallsview Casino is a vital part of Ontario's gambling strategy, said Economic Development Minister Joe Cordiano, the cabinet minister responsible for the Ontario Lottery and Gaming Corp. "This is our absolute jewel in the crown," Cordiano said. "We as a government, the McGuinty government, will make sure we promote that."

Government officials promoted the Fallsview Casino as the second-largest construction site in Canada and one of the largest public investments in provincial history. But Premier Dalton McGuinty was not on hand for the opening ceremonies. "I'm not sure what his schedule was... There's a lot of things going on in the legislature," said Cordiano.

The opening of the Fallsview Casino brings to about 6,500 the number of people directly employed by casinos in Niagara Falls.

galleries.
- A 368-room Hyatt hotel, including 85 VIP suites.
- 50,000 square feet of exhibition space.
- A 1,500-seat theatre.
- 10 dining and food facilities.
- A 3,000-car parking garage.
- A giant fountain paying tribute to Niagara's hydroelectric heritage.

During construction, builders of the Niagara Fallsview Casino used:
- 85,000 cubic metres of concrete.
- 10,500 pieces of glass.
- 7,500 tonnes of structural steel.
- 7,000 tonnes of reinforcing steel.
- Five tower cranes were on site in early construction.

The casino complex sits on 10 hectares of land overlooking the Horseshoe and American falls. The building contains:
- 34 elevators.
- 10,000 metres of sanitary drainage.
- 54 major air-handling units.
- Three steam boilers, four heating boilers.
- 31 heat exchangers.
- 212 supply and exhaust fans.

Source: Ontario Lottery and Gaming Corp., Falls Management Co.

10M fountain pays tribute to Niagara's hydroelectric heritage



drotenlatron is a massive tower of metal, acrylic, LED crystals, water and city.

STAFF PHOTO BY DENIS CAHILL

By JENNIFER PERGAMENT
Canwest News Networks
NIAGARA FALLS

Benjamin Franklin discovered electricity in June 1752.

In 1896, Nikola Tesla harnessed Niagara Falls to create electricity. Tuesday night, designer Larry Lester paid homage to Tesla's work, unleashing the Hydrotesla tron — a massive tower of metal, acrylic, LED crystals, water and electricity — during the grand opening of the Niagara Fallsview Casino Resort.

"First of all, it's named in honour of this being the epicentre of electricity," Lester said of his $10-million creation.

"No. 2 is to tie it to Tesla, who was instrumental in developing the alternate current."

The sunlight streaming through the enormous dome directly above the creation didn't do it justice, Lester said of the seven-minute dinnertime show, which featured sound effects, lasers and 19,000 litres of gushing water.

"The impact is about one-tenth of what it would be at nighttime," Lester said.

"The whole look of it is totally magnified about 50 times at night."

Lester said his past work designing art for Casino Rama and his history as a designer for Universal Studios and Vegas casinos led the Falls Management Company to ask him to construct a structure for the new Fallsview Casino back in 2002.

Using computers, Lester and his team at his Valencia, Calif., studio were able to design the parts to within five-thousandths of an inch.

The Hydrotesla tron was assembled in sections in California, then shipped to Niagara Falls in six trucks and erected without a hitch.

"We put it together and it all fit," Lester said.

That doesn't mean there aren't a couple of issues to iron out. Despite numerous after-hours tests over the past several weeks, Tuesday's shows were the first to be held with a room full of people, introducing a whole new dynamic — the impact of the crowd on sound.

"We'll have to build different shows, audio-wise, depending on how many people are here, but that's something we'll work out down the line," Lester said.

Lester's concerns went unnoticed by the crowd, which was awed by the structure.

While awaiting its transformation, spectators pointed out every transition the structure made.

"Oh, look at the lights," said one person.

"Wow, that's really something," said another.

The excitement lingered after the show was over.

"It's amazing. Isn't it amazing? It's just wonderful," gushed Sandy Gertner, who made the trip from Toronto to attend the opening-night gala with her friend, Bob Saks, owner of the Renaissance Hotel located across the road.

EVEN A CASINO GETS ON THE BANDWAGON

THE SUNDAY, 9 JUNE 2004

Tesla Memorial Society, Inc.
William H. Terbo
21 Maddaket, Southwyck Vlg.
Scotch Plains, NJ 07076-3136

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Mr. Jeffrey Behary
Turn of the Century Museum
2809 NE 15th Street
Pompano Beach, FL 33062

33062+3600

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076
10 October 2004

Photos from our trip to Serbia from September 12 through October 2, 2004

Boyana and I wish to thank the many friends and colleagues, old and new, we visited on our most recent trip to the "old" country and thank one and all for the exceptional hospitality shown to us.

I hope you will excuse this way of distributing some of the many photos we took during the trip. It is better to have these memories in hand without delay. If you have photos of Boyana and me that you think we would enjoy, please send them on or hold them for our trip next year.

It is impossible to mention everyone individually in this message but a few events deserve special attention. We were particularly pleased to dine with my "brother" the concert pianist Dusan Trbojevic and his wife, Gordana, and to meet with Society Executive Board member Momcilo Simic, in between his meetings at the ITU in Geneva.

As is our custom, we spent considerable time at the Nikola Tesla Museum in Belgrade and with Director, Marija Sesic. Visiting is, in a manner of speaking, reviewing our family patrimony, the essence and memorabilia of my father's uncle, Nikola Tesla. As usual, we were well received and look forward to the delivery of copies of some specific archive material we requested.

While in Kraljevo, Boyana's hometown, we attended the Press Premiere of Emir Kusturica's excellent new film *Zivot je Cudo (Life is a Miracle)* at the best theater in Serbia, the equal of the best in Beverly Hills, California. I expect the film to be nominated for an Academy Award in the category of "Best Foreign Language film."

We also visited the Director and faculty the Nikola Tesla Electrotechnical School, and met with students in several classes. We were the guests of many business, professional and political leaders in the area.

I want to thank the many print and TV journalists to whom we gave interviews.

Thanks again,

William and Boyana Terbo (Trbojevich) tmstk

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Visit our website: *teslamemorialsociety.org*

PRESS PHOTOS - ONLY ORIGINALS PRINT TO ME



AT PREMIERE RECEPTION EMIR KUSTURICA



INDUSTRIALIST & HOST OF RECEPTION

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

MICHAEL IDVORSKY PUPIN – 150TH ANNIVERSARY OF HIS BIRTH

The Tesla Memorial Society, Inc., its Executive Board and members join with all people who value the scientific and technological advances that have created the modern society in which we live in honoring the birth of Michael Pupin.

Michael Pupin, inventor, humanitarian and philosopher, is best known in the scientific community as the inventor of the Telephone Induction Coil (1899) a device that in one single step made long distance telephony possible. Sold in 1901 to the Bell System for an unprecedented sum that gave him the opportunity expand his vision beyond the field of his choosing. Also among Dr. Pupin's 34 U.S. patents were important radio developments and seminal work in Short Exposure X-Ray technology (1900) that led to the safe use of the new x-ray technology in medical diagnostics.

Michael Pupin was born on October 4, 1854 in the small village of Idvor in what is now a part of Serbia. He came to America at the age of 16 with only five cents in his pocket but with boundless energy. Within five years he had prepared himself for entry into Columbia College (University), graduated with honors, continued at Cambridge in England and received his Doctorate in Physics in Germany. He returned to a teaching position at Columbia where he soon founded the School of Electrical Engineering. Dr. Pupin remained associated with Columbia for the rest of his life. Shortly after his death on March 12, 1935 Columbia renamed the Physics building *Pupin Physics Laboratories*.

Dr. Pupin's Peace Conference advice to President Wilson was instrumental in resolving the borders that would define the new country that was to become Yugoslavia. Dr. Pupin served as the President of several important professional institutions including the New York Academy of Sciences, the American Institute of Electrical Engineers and the Radio Institute of America. Among his many honors was the Edison Medal (1920). Michael Pupin wrote three well-received books including the best selling autobiography of his fascinating life *From Immigrant To Inventor*, awarded the Pulitzer Prize in 1924.

On a personal note I wish to privately honor Michael Pupin on this significant year. Dr. Pupin was a personal friend and mentor of my father Nikola J. Trbojevich (Terbo) from the very time of father's arrival in America. It has been my privilege to honor Dr. Pupin several times in the past. I've attached a brief summary of that special connection.

William H. Terbo, Executive Secretary
(732) 396-8852

TMSsw2

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POINTS OF SPECIAL CONNECTION BETWEEN MICHAEL PUPIN AND WILLIAM TERBO THROUGH MY FATHER, NIKOLA TRBOJEVICH (TERBO)

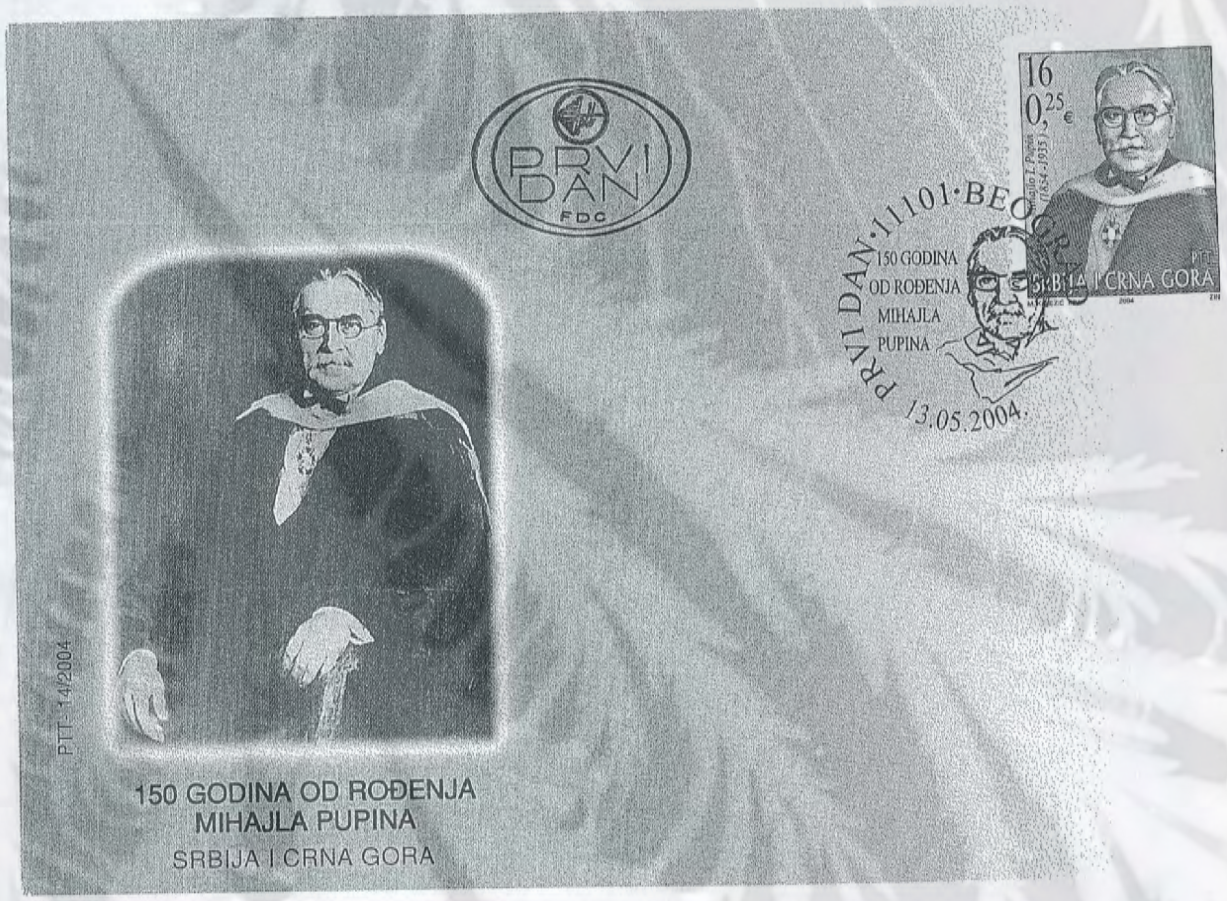
On the occasion of the 150th anniversary of the birth of Michael Pupin it is appropriate to recall some details of a nearly lifelong appreciation of a person who was held in special esteem by ones father, a person not related by blood but by an ethnicity combined with professional accomplishment.

- In the Terbo (Trbojevich) household during my youth the name of Michael Pupin was as often mentioned as that of father's uncle, Nikola Tesla.
- When my father arrived in New York in 1914 it was Michael Pupin who first met him. Pupin had a very specific policy of meeting and assisting talented Serbs when they arrived in America through New York City. This began a relationship that lasted until Pupin's death in 1935. In spite of my grandmother, Angelina Trbojevic (Tesla's older sister), who very strongly instructing Tesla to "take care of my boy" Tesla was temporarily occupied at the moment of father's arrival.
- While my father always indicated that he already had a position as Design Engineer at the AT&T Western Electric Division in Chicago before his arrival in New York, I believe Pupin, who had a most influential connection with AT&T, offered additional sponsorship help.
- Father's rise to scientific prominence (over 150 patents including the seminal invention of the Hypoid Gear) gave great pleasure to both Tesla and Pupin and gave father a continuing social and professional access to both men.
- In 1979, to commemorate the 125th Anniversary of Pupin's birth, I made my first trip to Yugoslavia to attend the Anniversary Celebration in Idvor, Pupin's birthplace, and other Yugoslav locations. My invitation was as an Honored Guest of the Country (together with the Pupin Professor of Physics at Columbia University, Madame C. S. Wu, and Isidor I. Rabi, 1944 Nobelist in Physics and a famous product of the Columbia Physics program).
- On October 5, 1979, I delivered my paper *Pupin and Tesla – Parallels In Slavic Creativity* to the related International Symposium *Life And Work Of Michael Idvorsky Pupin* at Novi Sad, Yugoslavia. (My hospitality included tours of the entire former Yugoslavia including visits to Tesla's birthplace, Smiljan, Lika.)
- In 1993, to honor my father and his relationship with Michael Pupin, and with the sponsorship of the Tesla Memorial Society, Inc. (where I held the positions of Chairman of the Executive Board and Honorary Chairman), we made the 50-minute documentary video *From Immigrant To Inventor, Michael Pupin Remembered.* I wrote the script and provided the narration, Ljubo Vujovic was Producer and Iwona Vujovic was Technical Director. The Documentary had its premiere at Columbia University that winter.

William H. Terbo, Executive Secretary
Tesla Memorial Society, Inc.
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076
(732) 396-8852

WHT/tmssu2

July, 2004


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From WILLIAM TERBO

11/19/03

JEFF:

I'VE TRIED TO ORGANIZE

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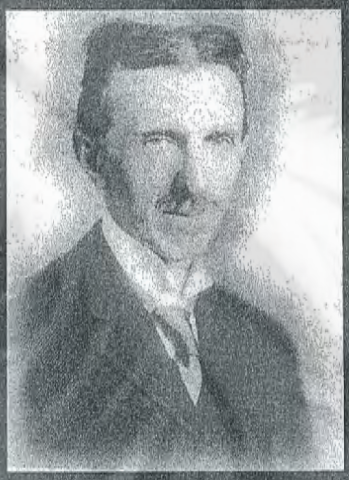
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HAPPY BIRTHDAY NIKOLA TESLA

1856 - 1943

Celebrating his life & genius



HOSTED BY
THE TOWN OF BROOKHAVEN

JOHN JAY LAVALLE, *Supervisor*
Brookhaven Town Council
Geraldine Esposito - Eugene Gerrard - Edward J. Hennessey
Charles Lefkowitz -Timothy P. Mazzei - James M. Tullo

NIKOLA TESLA DAY – JULY 10, 2003

PROGRAM AND PROCLAMATION
Hosted by The Town of Brookhaven, New York
John Jay LaValle, Supervisor

Remarks By

William H. Terbo
Executive Secretary, Tesla Memorial Society, Inc.

My appearance here today is a combination of an honor, a privilege and a duty.

When Nikola Tesla's monumental contributions to the modern industrial age and to the society it transformed are recognized, it is an honor I am given to accept that recognition in his name. Bringing Tesla's life and accomplishments to a wider public awareness through events such as this is a deed well done. I am pleased to participate.

It is a privilege I am given because one-quarter of my blood comes from the same source as Nikola Tesla's. My grandmother was his sister, Angelina. As Tesla never married and had children, I am (with one remaining cousin, Jovan) all that is left of this direct bloodline. I am doubly privileged to remember Tesla through my father, also a famous inventor, in that their parallel backgrounds of origin, education and immigration have given me a unique insight into their personalities from a personal and family point of view.

And third is the duty. It falls to me, through the Tesla Memorial Society, to do the best I can to help restore Tesla's name to just a fraction of the fame he enjoyed during his lifetime. Nikola Tesla was a superstar of 100 years ago, much as modern athletes and entertainers are superstars of today. His inventions were of immediate consequence. Tesla gained society's admiration by giving it the means to free itself from the punishing drudgery of another age. He helped make life worth living for legions indentured to a life of toil, and made retirement something to be looked forward to – rather than as a burden complicated by ill health and physical decline.

It is said that great ideas come when the world needs them. Nikola Tesla met that challenge many times. Radio, television and modern power generation, distribution and utilization are but the most known technologies revolutionized by his scientific creativity. While most inventors are recognized for a single step into the future, Tesla's contributions represent a steady march.

Tesla was an inspiration to generations, both for the ingenuity of his discoveries and for the purity of his ambitions. Many famous scientists of following generations enthusiastically acknowledged their debt to him. To the common man, Tesla represented the heights attainable through the product of ones own efforts.

While Tesla was a man of modern technology, he came from another, less commercial, age. The rewards he received were for furthering his work, rather than for his personal ease and comfort. The product of this work was for the ultimate benefit of society. In spite of his blaze of productivity, Tesla accomplished only a fraction of what he set out to do. His rewards, grand as they were, were insufficient to realize all of his creativity. Having fallen so far short of what he set as his goal, he thought himself unfulfilled.

But as Robert Browning wrote "A man's reach should exceed his grasp. Or what's a heaven for?"

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Tesla Memorial Society, Inc.
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076

WHT/tmsqk

Proclamation

Whereas: The Town of Brookhaven would like to honor the outstanding accomplishments of special individuals who have made a profound impact on our society; and

Whereas: July 10, 2003 marks the 147th birthday of the renowned scientist and genius Nikola Tesla; and

Whereas: We are priveledged to share residence in the Town where Nikola Tesla's Wardenclyffe Laboratory is situated; and

Whereas: Nikola Tesla's inventions have formed the foundation of modern science, thereby shaping the way we live today; now

Therefore I, John Jay LaValle, Supervisor of the Town of Brookhaven, join with my colleagues on the Town Council in proclaiming this 10th day of July as

Nikola Tesla Day

JOHN JAY LAVALLE,
Supervisor

GERALDINE ESPOSITO,
Councilwoman

EDWARD J. HENNESSEY,
Councilman

EUGENE GERRARD,
Councilman

CHARLES A. LEFKOWITZ,
Councilman

TIMOTHY P. MAZZEI,
Councilman

James M. Tullo
Councilman

The Village
TIMES HERALD
Stony Brook • Old Field • Strong's Neck • Setauket • East Setauket • South Setauket • Poquott
Volume XXVII, Number 27 September 19, 2002 75¢

Harvest Times
Look for our Fall fun guide *on newstands now*



Stony Brook Harbor
dredging — maybe yes, maybe no
Page A3

Tesla? Who's Tesla?
The underdog of electrical history
Page A11

Long Island to Plum Island
for bison and research into hoof and mouth
Page A15

Continued

Tesla

Continued from page A11

Swezey, whom this writer knew as a very young reporter for the Greenpoint (Brooklyn) *Star* in the late 1930s, started the Tesla Society and campaigned hard to get the United States to shower honors upon the inventor. A postage stamp was issued. Swezey's collection of Tesla's work, in 23 boxes, was donated to the Smithsonian Institute.

At Ann Arbor, Michigan a class of third- and fourth-graders are saving their pennies and soliciting funds to preserve Tesla's memory at 10 major colleges. They have already presented a bronze bust of the inventor to Yale's Becton Engineering and Applied Science Center.

A teacher at Summers-Knoll Elementary School went on the Internet to explain: "Our class hero is Nikola Tesla because he is the underdog of electrical history, yet his scientific discoveries brought us the prosperity we enjoy today."

Marconi's exploits got his name on boulevards in Middle Island and Babylon and an avenue in Islip, but a century after Tesla built his ill-fated tower, few people even know he ever existed.

Shoreham's moment in time was short-lived

Nikola Tesla's life was full of fame, intrigue, deceit and a denouement of broken dreams

BY JIM TUITE

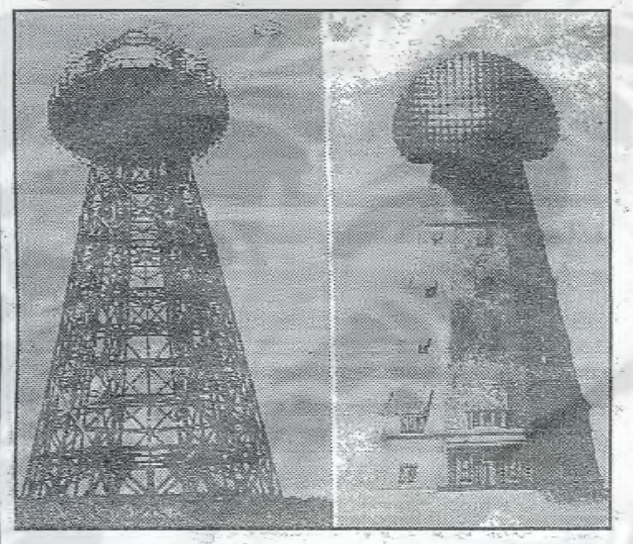
The road is less than 400 feet long and occupied by a single building, a dispatch center for the Shoreham Fire Department. It's called Tesla Street, hardly an impressive memorial to a Nobel Prize winner who held hundreds of patents and helped to introduce the fundamentals of computers and missile science to the world. Who was Nikola Tesla?

"Wasn't he an opera singer or something?" guessed a schoolboy riding his bike on nearby Route 25A.

Few people passing Tesla's former laboratory between Randall Road and Tesla Street (which later became the Peerless Photo site that was abandoned for its ground contamination) realize he was considered by many of his peers to be the world's foremost inventor.

Some people called him a mad genius. As an actor of courtly grace, he might have been cast in the *Phantom of the Opera*. A lifelong bachelor, over six feet tall and dark of mien with brooding, deep-set eyes, he had a Slavic accent that defined his Croatian origin.

The phantom image was enhanced when, after Tesla's departure, many interlocking tunnels were found under his laboratory and the adjoining Shoreham area. Tesla's story would have been grist for the mill of any Hollywood writer. There was achievement, worldwide fame, intrigue, deceit, treachery and a denouement of broken dreams and failures. He charmed the ladies and, a naturalized American, shrugged off overtures from the Soviet Union and Germany for his services.



At left is the Tesla Tower when the inventor ran out of money. At right is the artist's conception of the tower had it been finished.

Even life and death provided a dramatic backdrop for Tesla. He was born at midnight on July 9 in 1856 and died 87 years later (some say during an electrical storm) again at the stroke of midnight.

The man who had helped to solve the mystery of wireless technology with seed money from J.P. Morgan, Westinghouse and other wealthy investors, became cash poor at one point and spent his days feeding peanuts to pigeons in Central Park.

The man who had arrived in this country in 1884 with four pennies in his pocket and dug ditches to live, admitted in court in 1916 that he failed to pay $935 in personal state taxes and lived on credit at the Waldorf-Astoria Hotel.

A museum in Belgrade, containing 150,000 of his documents, stands in tribute to this Croatian whose genius earned him a street sign in Shoreham. Yet it was in a quiet, little hamlet, just 100 years ago, that a strange-looking tower survived briefly as a symbol of Shoreham's date with destiny.

It was known as the Tesla Tower and rose from a 200-acre site called Wardenclyffe, once part of the Randall and Hegeman properties. The purpose: to prove Tesla's thesis that electronic signals could be transmitted all over the world without using wires.

The tower was topped by a copper electrode that looked like the cap of a huge mushroom, 100 feet in diameter. The structure tower rose 187 feet above ground, set in a steel shaft imbedded 120 feet into the earth. According to one report, the townspeople of Shoreham "believed themselves to be on the brink of fame and industrial prosperity." It was dismantled in 1917.

As 1902 was dawning, word arrived from Europe that an Italian, with a three-dot radio transmission, had won the race for wireless communication. The three dots signified letter S transmitted in Morse code, and Guglielmo Marconi was credited with the prize Tesla so dearly sought.

In an effort to retrieve his reputation, and with war clouds looming over Europe in 1917, he offered an invention as a kind of *Star Wars* defensive measure, "a parallel to Thor's shooting thunderbolts from the sky to punish those who had angered the gods.



Nikola Tesla

"Ten miles or a thousand miles, it will be all the same to the machine ... delivering a blow that will paralyze or kill, as it is desired," he said, and specified that "a man in a tower on Long Island could shield New York against ships and troops." Some might call it a "death ray."

Few people knew that Marconi had utilized Tesla's radio patents to facilitate his project, and the Shoreham-based inventor talked about "Borgia-Medici" methods that were depriving him of money and credit.

With Morgan's upfront loan of $150,000 nearly gone (the American backer was to get 51 percent of the profits) and Marconi expanding his experiments with ship-to-shore wireless in April of 1902, Tesla became depressed, his friends say.

Through all of this, and himself an anomaly, he was a self-effacing, self-taught bachelor who lived in a cold-water flat in Brooklyn until he died in 1943. Tesla studied in European capitals, but Kenneth M. Swezey was a drop-out from junior high who wrote on complicated scientific subjects for the old *New York Sun* and other publications.

Swezey, Tesla's biographer and close friend, spoke of his guru in almost spiritual terms. "He was amazing," Swezey said. "He could picture inventions in his mind and then work backward, transferring them to paper."

One biographer reported that while Tesla was walking through a park in Budapest, the inventor's mind was struck "like a thunderbolt" with the answer to the problem of a magnetic rotating field. Using a stick, the legend goes, he drew diagrams in the sand and outlined the principles for the induction motor.

Continued on page A26

Tesla, a Little-Recognized Genius, Left Mark i

By JOHN RATHER

IT'S a safe bet that relatively few people on Long Island have heard of Nikola Tesla, the world-shaking electrical genius whose invention of polyphase alternating current made him, more than anyone, the man who electrified the 20th century.

Even fewer people are likely to know that Tesla did some of his most visionary work in a laboratory built for him in Shoreham exactly a century ago by Stanford White, the Gilded Age architect who was a friend and admirer.

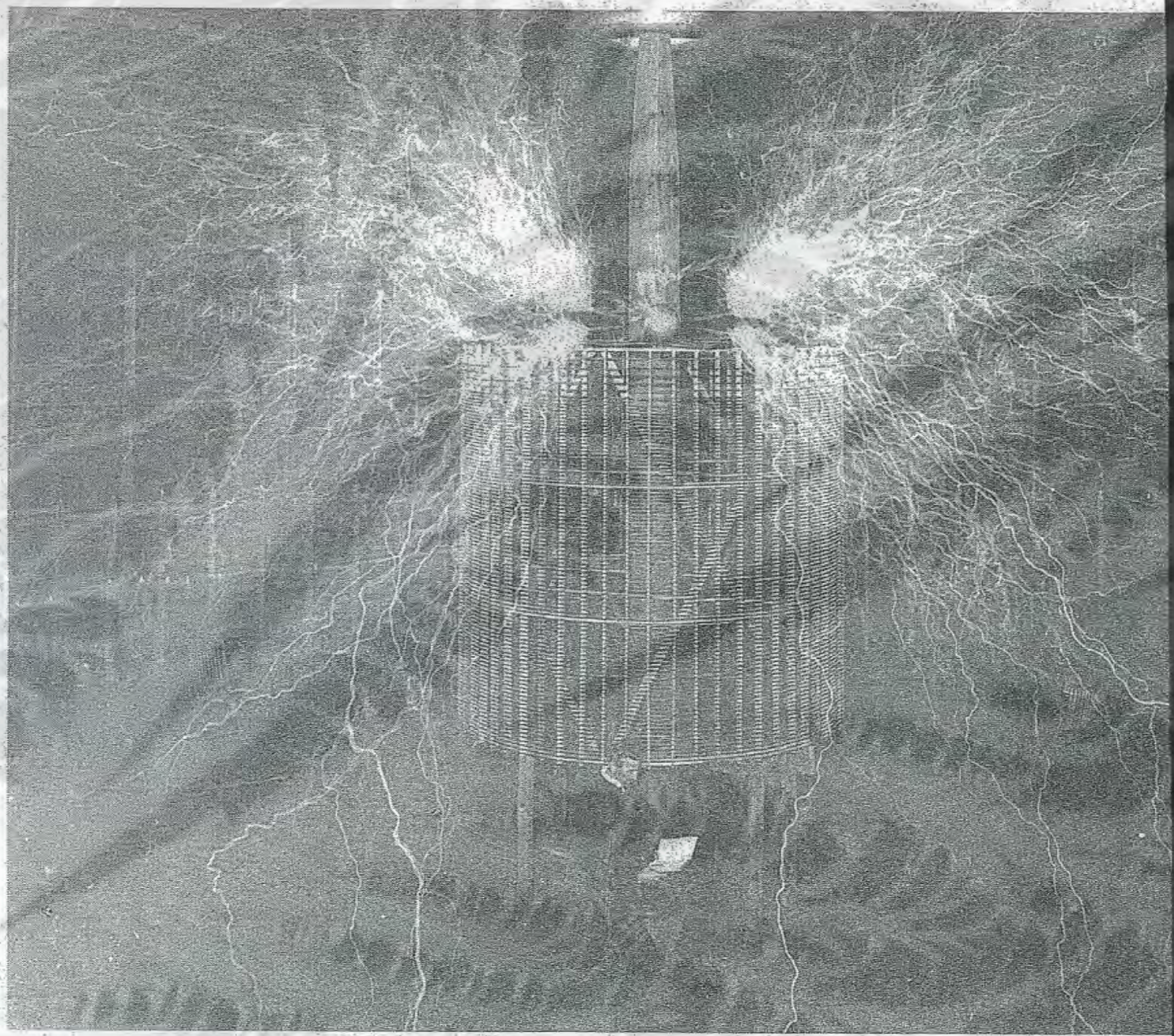
And it would be a surprise to almost everyone that the 94-by-94-foot laboratory, known as Wardenclyffe and envisioned by Tesla as a prototype for a stupendous world communications and wireless electric system, is still standing and in relatively good shape only yards from Route 25A, a major state highway.

Today the laboratory's red-brick facade is barely visible through overgrown foliage from a fence around the 16.2-acre property. The unused site, now owned by Agfa-Gevaert, the Belgian photographic film giant, is closed to the public. It is undergoing a state-ordered cleanup for soil and groundwater contamination linked to Peerless Photo Products, a previous owner that was acquired by Agfa.

A security guard who never heard of Nikola Tesla turned away visitors on a recent afternoon. The property, he said, was unused and sealed shut while the owners decided what to do with it.

Hanging in the balance, Tesla historians and preservationist said, is the fate of the last intact Tesla workplace anywhere in the world and a gem of Long Island history too long left in the rough.

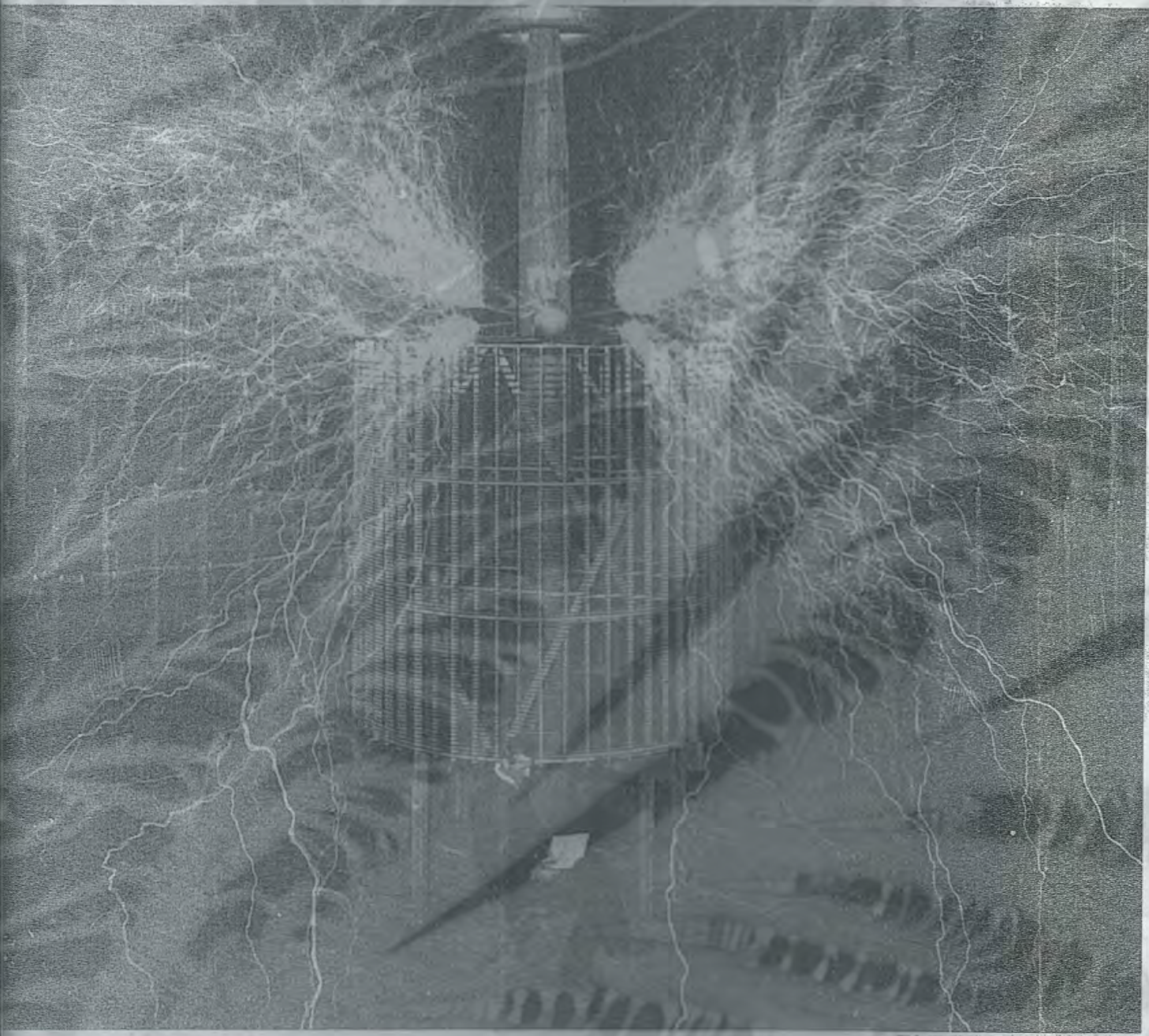
"This is an extremely important landmark," said Barbara Van Liew, an architectural historian from St. James. "By all means, it should be



Dickenson V. Alley/Tesla W

Interior of the Colorado Springs Experimental Station in which Nikola Tesla sits next to the extra coil of his large magnifying transm

e-Recognized Genius, Left Mark in Shoreham



Dickenson V. Alley/Tesla Wardenclyffe Project

he Colorado Springs Experimental Station in which Nikola Tesla sits next to the extra coil of his large magnifying transmitter in 1899.

fers on the site, ranging from developers to Tesla-related societies," said the statement by Robert Hoffmann, director of general services and facilities for the Agfa Corporation in Ridgefield Park. But, he added, the property is not now under contract or listed with any broker.

Mr. Hoffmann said that the site was structurally sound and that company officials were aware of its historic significance.

The company declined to support listing it on state and national registers of historic places. Once the property is sold or donated, applying for that designation would be up to the new owner, Mr. Hoffmann said.

As long ago as 1967, the Town of Brookhaven named the laboratory property a historic site. But no formal application has been made for the state designation, a precursor to the federal designation.

James P. Warren, a historic preservation program analyst for the New York State Office of Parks, Recreation and Historic Preservation, said owner consent was usually required for a listing on the state regis-

A rival of Edison's without the financial backing.

ter and always required for the national register. He said the property was eligible for both. Merely being associated with White is significant, he said.

Wardenclyffe may have been White's last creation. In 1906 he was shot and killed by the jealous husband of a former chorus girl, Evelyn Nesbit, at the original Madison Square Garden, which he designed.

Tesla, born in 1856 in Croatia,

preserved. Tesla invented a lot of the things we use today, and he doesn't get much credit."

In perfecting the alternating-current power system now used around the world, Tesla prevailed over Thomas Edison, who believed in an inferior direct-current system and strove in vain to prove that alternating current was unsafe.

It was Tesla, not Marconi, who invented radio. He also harnessed Niagara Falls for hydropower and invented, among many other things, a bladeless steam turbine, the first remote-controlled torpedoes and devices that had applications in missile defense and computers, long after his death in 1943.

Now the race is on to preserve Tesla's legacy and White's architecture in Shoreham.

Two groups, the Tesla Wardenclyffe Project, a national organization based in Colorado, and Friends of Science East in Shoreham, are hoping to have the site listed on the state and national registers of historic places. Their plans also call for establishing a Nikola Tesla Science Center in the laboratory building, where Tesla memorabilia would be put on display.

The groups are asking Agfa to donate the site to the Town of Brookhaven, where Shoreham is situated, to clear the way for the historic listings and the science center.

But Agfa has been noncommittal, and the standstill is likely to persist until the environmental remediation is complete. The State Department



Tesla Wardenclyffe Project

The Wardenclyffe Laboratory/ Power Plant in Shoreham in 1904

of Environmental Conservation, which is overseeing the cleanup, recently asked for more testing for possible contamination. It is not clear when all work will be done.

"At this point everything is between Agfa and the state," said Gary Peterson, a spokesman for the Tesla Wardenclyffe Project in Breckenridge, Colo. "But Agfa has let us know they are aware of the historic significance of the Wardenclyffe site and that they did not intend to do anything untoward."

Jane Alcorn, the president of Friends of Science East, said a recent study done by Shoreham residents envisioned the Tesla site as a center for the hamlet and a place to



Maxi

The Tesla laboratory site in 1997; preservationists are urging the owner to donate it to Brookhaven.

teach children about science.

"Not that many towns on Long Island have a Stanford White building," she said. "For that alone it's worth preserving." Charla Bolton of the Society for the Preservation of Long Island Antiquities in Cold Spring Harbor agreed. "There is no question, it is worthy of preservation," she said.

But the groups and others familiar with the property are concerned that Agfa may decide to sell to a dev er once the cleanup is over.

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Maxine Hicks

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lived in Manhattan hotels for most of his life. He was already an acclaimed inventor when he arrived in Shoreham in 1902. He was fleeing Manhattan, where his celebrity had begun to interfere with work in his laboratory on Houston Street, for the solitude of the Long Island countryside. The new laboratory was financed with $150,000 from J. P. Morgan, who expected to make a fortune on Tesla's work.

Somewhere in the undergrowth at the Shoreham site are remnants of the concrete footings for the 187-foot radio and electrical transmission tower that a White associate, J. D. Crow, erected for Tesla in 1903.

The octagonal wood-frame tower, perched over a 120-foot underground shaft, was the core of a generating system designed to use the earth and the upper reaches of the atmosphere as conductors of electrical impulses that would reach around the globe.

From 1903 until it was razed in 1917, the never-quite-completed tower rose like a giant mushroom over eastern Long Island and could be seen from across the Sound in Connecticut.

Tesla's experiments faltered when Morgan declined to invest more money. Tesla struggled on, mortgaging the property to raise cash. But by 1915 he was out of money, and the property went into foreclosure. He remained convinced that success had been at hand. It is a simple feat of scientific electrical engineering, only expensive, he wrote. Blind, faint-hearted, doubting world.

Newsday

NAMES OF LONG ISLAND

THE STORIES BEHIND THE NAMES OF LONG ISLAND'S TOWNS, ROADS, LANDMARKS AND MORE



Photo: Dover Dictionary of American Portraits

Nikola Tesla (1856-1943)

Photo: Cathy Salamone

Tesla Street, which runs northeast of Route 25A in East Shoreham, is named for physicist and inventor Nikola Tesla, whose research served as the basis for much of today's technology. In 1901, with financing from J.P. Morgan, Tesla began building a World Telegraphy Center on a former 200-acre potato field across from Shoreham's railroad station. The project was designed by famed architect Stanford White and included a 180-foot radio tower and a large laboratory. The effort failed because of financial problems, and the tower was destroyed in 1917.

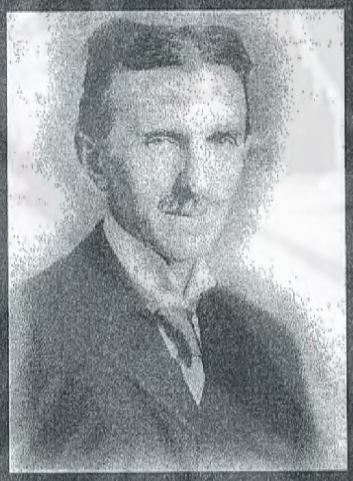
—Cynthia Blair

Names of Long Island is a daily promotional feature produced by the Newsday Marketing Department.

HAPPY BIRTHDAY NIKOLA TESLA

1856 - 1943

Celebrating his life & genius



HOSTED BY

THE TOWN OF BROOKHAVEN

JOHN JAY LAVALLE, *Supervisor*

Brookhaven Town Council

Geraldine Esposito - Eugene Gerrard - Edward J. Hennessey

Charles Lefkowitz -Timothy P. Mazzei - James M. Tullo

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

A&E Biography Honors the 15 Greatest Inventors of the 20th Century

The Arts & Entertainment Television Networks premiered a Special one-hour program ***The Top 15 Inventors of the 20th Century*** on Tuesday, June 4, 2002. The program was one of a number of *A&E Biography 15th Anniversary* Specials to recognize the various subject categories covered over the life of the series.

The "Top 15" were selected and ranked through a poll of 250 journalists, inventors and academics as the "most influential inventors of the last 100 years" who "brought us from the industrial age to the information age." While most of those chosen were known for just a single innovation, the selections were also based on the contributions of an entire career. (For dramatic effect, the inventors were presented in reverse order ranking on the program.) The Top 15 and their specific contributions (in a necessarily simple and brief manner) were:

1. Thomas Edison for various inventions.
2. Orville and Wilbur Wright for the airplane.
3. William Shockley (with John Bardeen and Walter Brattain) for the transistor.
4. Philo Farnsworth for television.
5. Jonas Salk for the Polio vaccine.
6. Leo Baekeland for plastics.
7. Nikola Tesla for alternating current.
8. Alan Turing for the computer.
9. Gregory Pincus for the birth control pill.
10. Leo Szilard for the atom bomb.
11. Gordon Gould for the laser.
12. Henry Ford for the assembly line.
13. Guglielmo Marconi for the radio.
14. Stanley Cohen and Herbert Boyer for genetic engineering.
15. Tim Berners-Lee for the World Wide Web.

The pace of the program was hectic. After deducting for an opening, five commercial breaks, intermediate list reviews and recaps, a closing and end credits only about 40 minutes remained for brief sketches of each of the 15 honorees. Those sketches, which ran from about two minutes to just over three minutes each, had to cover the impact of the inventors contribution on society, the relation of the inventor's technology to similar or competing technologies, the source or method of inspiration, the breadth of the inventors genius and personality and other items needed for clarification.

The program host, correspondent Harry Smith, guided the sketches each of which included on-camera interviews with personalities commenting on aspects of the inventor's work or life. Those commenting ranged from people with specific technical

credentials such as John Rennie, Editor in Chief of Scientific American and George Campbell, President of Cooper Union, to industry leaders like Steve Case, Chairman of AOL Time Warner, to popular personalities like radio host, Don Imus and musician, Sean Combs. Personal insights were provided by some of the inventors themselves (Tim Berners-Lee, Stanley Cohen, Herbert Boyer and Gordon Gould) or close relatives of the inventors (Pem Farnsworth, widow of Philo Farnsworth and William Terbo, grandnephew of Nikola Tesla).

No list or ranking can satisfy everyone. If the list were to exclude inventions patented before the 20th Century, Thomas Edison might not have appeared at all. If the inventions were judged specifically on their impact on the 20th Century, it would be impossible to ignore Alexander Graham Bell. If inventors were measured by (patented) inventions, Henry Ford would have to be excluded and Tim Berners-Lee would not make the cut. If the ranking were based on life's work, Nikola Tesla would rank at or near the top – if based only on 20th Century patents, Tesla's ranking at number seven is about right.

Edison's position as the American Icon for technology remains intact. The program maintains this image by including "Some people say he single-handedly invented the 20th Century" and " He was not the best inventor – or even the smartest – he was tenacious." For the sheer volume of patents (1,032) he is unchallenged. The support for top ranking was (in order mentioned): the phonograph, reworking the ordinary light bulb to the incandescent bulb, the movie camera, film sound synchronization, the stock ticker, the mimeograph, telephone improvements, the first U.S. power plant and Portland Cement. While the impact of the light bulb, phonograph and movie camera on the 20th Century is undeniable, only together do they make a foundation for high ranking.

The program accords Nikola Tesla praise that is often overlooked. Host Harry Smith opens the Tesla sketch with "The man who made possible most of our modern uses of electricity – Thomas Edison? No! It's Nikola Tesla!" Edison was called "a stubborn and unyielding taskmaster" and the "War of the Currents" went to Tesla. Scientific American Editor in Chief, John Rennie calls Tesla "One of the most wildly inventive minds that the world has ever seen." "He was hugely influential – to say the least – in creating Alternating Current and thereby setting a standard for all of the electrical power grid that we know today." The AC victory opened the door to Tesla's advances (as mentioned in the sketch) in radio, remote control and other inventions ranging from radar to neon lights.

The Tesla Memorial Society supported the producers of *The Top 15 Inventors of the 20th Century.* This included providing photographs and documents to assist in creating the Tesla program sketch and a studio on-camera interview with Society Executive Secretary, William Terbo. The photos were widely used by the producers and A&E in the program network promotional clips as well as in the actual production opening and Tesla sketch segment. This gave the image of Nikola Tesla much more airtime and meets the Society objective of personalizing Tesla for the general public. The program included end credits for the Society, the Nikola Tesla Museum (Belgrade) and William Terbo.

TMSol

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Czech Ministry of Education To Produce Video Program On Nikola Tesla

The Czech Republic Ministry of Education has arranged to produce a short video on the life of the famous inventor, Nikola Tesla. The video is to be shown to Czech students at the High School level to familiarize them on the accomplishments of this giant of electrical science who received a substantial part of his higher education in Prague. Just as in the United States, the Ministry had become aware that very few young students knew of Tesla's fundamental contributions to modern society through his seminal work on electricity and radio.

A crew from Fontis TV Production, Prague, arrived in the United States in early May 2002, to produce segments for the video. Travel details and visit arrangements were coordinated by the Society. Their schedule included location work in Manhattan, Scotch Plains and Niagara Falls (New York and Ontario, Canada).

Society Executive Secretary William Terbo guided the Fontis crew in Manhattan and provided on-camera descriptions of the Tesla sites. Visited were:

- The Radio Wave Building, 49 West 27th Street, (now a professional office building, but formally The Gerlach a, then new, luxury residential hotel) where Tesla lived from 1892 through 1899. A plaque commemorating Tesla was installed in 1977. The modern lobby features four large photographic murals including two concerning early electric energy themes.
- The Hotel New Yorker, Eighth Avenue at 34th Street, Tesla's residence from 1934 to his passing in January, 1943. While the Hotel has had many redecorations and modernizations, the lobby foyer still retains many of the luxury details that were present in Tesla's time. A large plaque commemorating Tesla was installed on the 34th Street exterior of the Hotel in 2001.
- Nikola Tesla Corner, Avenue of the Americas (Sixth Avenue) at 40th Street, dedicated by the City of New York in 1994. Also visited was 8 West 40th Street, a modernized office building where Tesla maintained offices from 1915 through 1925. (Bryant Park, between Sixth Avenue and the Main New York Public Library from 40th to 42nd Streets, is the site where Tesla most famously fed his pigeons.)
- The Cathedral of St. John the Devine, Amsterdam Avenue at 112th Street, where the State Funeral for Tesla was held in 1943. Among the over 2,000 attending were prominent representatives the international cultural, scientific and governmental communities. (A New York landmark and still under construction after 110 years, St. John the Devine is the largest Gothic Cathedral in the world.)

The Fontis crew conducted an on-camera interview with William Terbo, grandnephew of Nikola Tesla, at his home (and Society headquarters) in Scotch Plains, New Jersey (New

York City Metropolitan Area). They also reviewed memorabilia, documents and photographs from the Society and Terbo personal collections.

Society Executive Board member Mr. Dan Mrkich guided the Fontis group at Niagara Falls and provided detail background of the sites. Visited were:

- Nikola Tesla statue in the Goat Island State Park, prominently located in an area between the American and International "Horseshoe" Falls. The statue was the 1976 U.S. Bicentennial gift of the Yugoslav Government to the American Government. Tesla is the only personage represented in the Park. Other plaques and structures recognizing the original 1890-96 Niagara Falls AC power construction are located adjacent to the Tesla statue.
- Niagara Falls Ontario for historical markers and superior views of the Niagara Falls. Unfortunately, a proposed tour of the 1905 Canadian power plant in (reserve) operation could not be accomplished at this time due to heightened security measures.
- Niagara River on the "Maid of the Mists." This boat tour approaches the foot of Niagara Falls from the river level and can provide dramatic effect for the video.

The Fotis crew is scheduled to visit the Nikola Tesla Museum in Belgrade in September to conclude segments on the Czech Republic Ministry of Education video.

By mutual understanding, Fotis TV Productions is to provide several items including appropriate video end credits as specified by the Society and to provide two copies of the completed video (in North American VHS format) for Society archival use.

TMSoka

THE PATENTS OF NIKOLA TESLA, BY COUNTRY

Argentina –1, Australia – 16, Austria – 4, Brazil – 2, Canada –1, Cuba – 1, Denmark – 1, France – 13, Germany – 14, Great Britain – 16, Hungary – 7, India – 1, Italy – 11, Japan – 1, Mexico – 1, New Zealand – 1, Russia – 4, South Africa – 1, Spain – 4, Sweden – 2, Switzerland – 4, Zimbabwe – 1, and the following 112 Patents registered in the United States.

Patent #	Title	Date of filing	Date of registry
334823	Commutator for Dynamo Electric Machines	May 6, 1885	Jan. 26, 1886
335786	Electric Arc Lamp	Mar. 30,1885	Feb. 9, 1886
335787	Electric Arc Lamp	July 13, 1885	Feb. 9, 1886
336961	Regulator for Dynamo-Electric Machines	May 18, 1885	Mar. 2, 1886
336962	Regulator for Dynamo-Electric Machines	June 1, 1885	Mar. 2, 1886
350954	Regulator for Dynamo-Electric Machines	Jan. 14, 1886	Oct. 19, 1886
359748	Dynamo-Electric Machines	Jan. 14, 1886	Mar. 22, 1887
318968	Electro-Magnetic Motor	Oct. 12, 1887	May 1, 1888
381969	Electro-Magnetic Motor	Nov. 30, 1887	May 1, 1888
381970	System of Electrical Distribution	Dec. 23, 1887	May 1, 1888
382279	Electro-Magnetic Motor	Nov.30, 1887	May 1, 1888
382280	Electrical Transmission of Power	Oct. 12, 1887	May 1, 1888
382281	Electrical Transmission of Power	Nov. 30, 1887	May 1, 1888
382845	Commutator for Dynamo-Electric Machines	April 30, 1887	May 15, 1888
390413	System of Electrical Distribution	April 10, 1888	Oct. 2, 1888
390414	Dynamo-Electric Machine	April 23, 1888	Oct. 2, 1888
390415	Dynamo-Electric Machine or Motor	May 15, 1888	Oct. 2, 1888
390721	Dynamo-Electric Machine	April 28, 1888	Oct. 9, 1888
390820	Regulator for Alternate Current Motors	April 24, 1888	Oct. 9, 1888
396121	Thermo-magnetic Motor	Mar. 30, 1886	Jan. 15, 1889
401520	Method of Operating Electro-Magnetic Motors	Feb.18,1899	Apr. 16, 1889
405858	Electro-Magnetic Motor	Jan. 8, 1889	June 15, 1889
405859	Method of Electrical Power Transmission	Mar. 14, 1889	June 25, 1889
406968	Dynamo Electric Machine	Mar. 23, 1889	July 16, 1889
413353	Method of Obtaining DC from AC	June 12, 1889	Oct. 22, 1889
416191	Electro-Magnetic Motor	May 20, 1889	Dec. 3, 1889
416192	Method of Operating Electro-Magnetic Motors	May 20, 1889	Dec. 3, 1889
416193	Electro-Magnetic Motor	May 20, 1889	Dec. 3, 1889
416194	Electric Motor	May 20, 1889	Dec. 3, 1889
416195	Electro-Magnetic Motor	May 20, 1889	Dec. 3, 1889
417794	Armature for Electric Machines -(Tesla - Schmidt co-inventors)	June 28, 1889	Dec. 24, 1889
418248	Electro-Magnetic Motor	May 20, 1889	Dec. 31, 1889
424036	Electro-Magnetic Motor	May 20, 1890	March 25,1890
428057	Pyromagneto-Electric Generator	May 26, 1887	May 13, 1890
433700	Alternating Current Electro-Magnetic Motor	Mar. 26, 1890	Aug. 5, 1890
433701	Alternating Current Motor	Mar. 26, 1890	Aug. 5, 1890
433702	Electrical Transformer or Induction Device	Mar 26,1890	Aug. 5, 1890
433703	Electro-Magnetic Motor	April 4, 1890	Aug. 5, 1890
445207	Electro-Magnetic Motor	May 20,1889	Jan. 27, 1891
447920	Method of Operating Arc Lamps	Oct. 1, 1890	Mar. 10,1891
447921	Alternating Electric Current Generator	Nov. 15, 1890	Mar. 10, 1891
454623	System of Electric Lighting	Not known	June 26, 1891
454622	System for Electric Lighting	April 26, 1891	June 23, 1891
455067	Electro-Magnetic Motor	Jan. 27,1891	June 30, 1891
455068	Electrical Motor	Mar. 27, 1891	June 30,1891
455069	Electric Incandescent Lamp	May 14, 1891	June 30, 1891
459772	Electro-Magnetic Motor	April 6,1889	Sept.22, 1891
462418	Method of and Apparatus for Electrical Conveyors & Distribution	Feb. 4, 1891	Nov. 1, 1891
464666	Electro-Magnetic Motor	July 13, 1891	Dec. 8, 1891
464667	Electrical Condenser	Aug. 1,1891	Dec. 8, 1891
487796	System of Electrical Transmission of Power	May 15, 1888	Dec. 13, 1892
511559	Electrical Transmission of Power	Dec. 8,1888	Dec. 26, 1893
511560	System of Electrical Power Transmission	Dec. 8,1888	Dec. 26,1893
511915	Electrical Transmission of Power	May 15,1888	Jan. 2, 1894
511916	Electric Generator	Aug.19,1893	Jan. 2,1894
512340	Coil for Electro-Magnets	July 7, 1893	Jan. 9, 1894
514167	Electric Conductor	Jan. 2, 1892	Feb. 6, 1894
514168	Means for Generating Electric Currents	Aug. 2, 1893	Feb. 6, 1894
514169	Reciprocating Engine	Aug.19,1893	Feb. 6, 1894
514170	Incandescent Electric Light	Jan. 2, 1892	Feb. 6, 1894
514972	Electric Railway System	Jan. 2, 1892	Feb. 20, 1894
514973	Electric Motor	Dec. 15, 1893	Feb. 20,1894
517900	Steam Engine	Dec.29, 1893	April 10,1894
524426	Electromagnetic Motor	Oct.20,1888	Aug.14,1894
555190	Alternating Motor	May 15,1888	Feb. 25, 1896
567818	Electric Condenser	June 17,1896	Sept.15,1896
568176	Apparatus for Producing Electric Currents of High Frequency and Potential	April 22,1896	Sept.22,1896
558177	Apparatus for Producing Ozone	June 17,1896	Sept.22,1896
568178	Method of Regulating Apparatus for Producing Currents of High Frequency	June 20,1896	Sept.22,1896
568179	Method of and Apparatus for Producing Currents of High Frequency	July 6,1896	Sept.22,1896
568180	Apparatus for Producing Electrical Currents of High Frequency	July 9,1896	Sept.22,1896
577670	Apparatus for Producing Electrical Currents of High Frequency	Sept.3,1896	Feb.23, 1897
577671	Manufacture of Electrical Condensers, Coils, etc	Nov.5, 1896	Feb.23, 1897
583953	Apparatus for Producing Currents of High Frequency	Oct. 19, 1896	June 8, 1897
593138	Electrical Transformer	Mar. 20, 1897	Nov. 2, 1897
609245	Electrical-Circuit Controller	Dec. 2, 1897	Aug. 16, 1898
609246	Electric-Circuit Controller	Feb. 28, 1898	Aug. 16,1898
609247	Electric-Circuit Controller	Mar. 12,1898	Aug.16,1898
609248	Electric-Circuit Controller	Mar. 12,1898	Aug.16,1898
609249	Electric-Circuit Controller	Mar. 12,1898	Aug.16,1898
609250	Electric Igniter for Gas-Engines	Feb.17,1897	Aug.16,1898
609251	Electrical-Circuit Controller	June 3, 1897	Aug.16,1898
611719	Electrical-Circuit Controller	Dec.10, 1897	Oct. 4, 1898
613735	Electric Circuit Controller	April 19,1898	Nov.8,1898
613809	Method of and Apparatus for Controlling Mechanism of Moving Vessels or Vehicles	July 1,1898	Nov. 8, 1898
613819	Filings Tube	Not Known	Nov. 8, 1898
645576	System of Transmission of Electrical Energy*	Sept.2,1897	March 3,1900
649621	Apparatus for Transmission of Electrical Energy*	Sept.2,1897	May 15, 1900
655838	Method of Insulating Electric Conductors	June 15, 1900	Aug. 14, 1900
685012	Means for Increasing the Intensity of Electrical Oscillations	Mar. 21, 1900	Oct.22, 1901
685953	Method of intensifying and Utilizing Effects Transmitted Through Natural Media	June 24, 1899	Nov. 5, 1901
685954	Method of Utilizing Effects Transmitted Through Natural Media	Aug. 1, 1899	Nov. 5, 1901
685955	Apparatus for utilizing Effects Transmitted From a Distance to a Receiving Device Through Natural Media	June 24, 1899	Nov. 5, 1901
685956	Apparatus for Utilizing Effects Transmitted Through Natural Media	Aug. 1, 1899	Nov. 5, 1901
685957	Apparatus for the Utilization of Radiant Energy	Mar. 21, 1901	Nov.5, 1901
685958	Method of Utilizing Radiant Energy	Mar. 21, 1901	Nov. 5, 1901
723188	Method for Signaling	July 16,1900	Apr. 14 1903
725605	System of Signaling	July 16, 1900	Apr. 14,1903
787412	Art of Transmitting Energy Through the Natural Medium	May 16,1900	Apr. 18, 1905
1061142	Fluid propulsion	Oct. 21, 1909	May 6, 1913
1062206	Turbine	Oct. 21, 1909	May 6, 1913
1113716	Fountain	Oct. 28, 1913	Oct. 13, 1914
1119732	Apparatus for Transmitting Electrical Energy**	Jan. 8, 1902	Dec. 1, 1914
1209359	Speed Indicator	May 29, 1914	Dec. 19, 1916
1266175	Lighting-Protector	May 6, 1916	May 14, 1918
1274816	Speed Indicator	Dec. 18,1916	Aug. 8, 1918
1314718	Ship's Log	Dec. 18, 1916	Sept. 2, 1919
1329559	Valvular Conduit	Feb. 21, 1916	Feb. 3, 1920
1365547	Flow Meter	Dec. 18, 1916	Jan. 2, 1921
1402025	Frequency Meter	Dec. 18, 1916	Jan. 3, 1922
1655113	Method of Aerial Transportation	Sept. 9, 1921	Jan. 3, 1928
1655114	Apparatus for Aerial Transportation	Oct. 4, 1927	Jan. 3, 1928

*These two patents are the basis of modern wireless communications. Tesla was a perfectionist, and Guillermo Marconi, a more commercial man, *got a jump* on him, using, or in Tesla's words, "pirating, seventeen of his patents" on his way to fame and fortune. But on June 21, 1943, five months after Tesla's death, the Supreme Court of the United States annulled Marconi's patent, and handed down the decision that Tesla "had anticipated all other contenders... thus making subsequent patents on the subject null and void," and proclaimed Nikola Tesla the true inventor of radio.

**Twelve years to register this patent! Westinghouse Company – "whose business is largely founded on my inventions," said Tesla – exploited this invention "by force".

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Proclamation

Whereas: The Town of Brookhaven would like to honor the oustanding accomplishemnts of special indibiduals who habe made a profound impact on our society; and

Whereas: July 10, 2003 marks the 147th birthday of the renowned scientist and genius Nikola Tesla; and

Whereas: We are priveledged to share residence in the Town where Nikola Tesla's Wardenclyffe Laboratory is situated; and

Whereas: Nikola Tesla's inventions habe formed the foundation of modern science, thereby shaping the way we live today; now

Therefore I, John Jay LaValle, Supervisor of the Town of Brookhaven, join wiht my colleagues on the Town Council in proclaiming this 10th day of July as

Nikola Tesla Day

JOHN JAY LAVALLE,
Supervisor

Geraldine Esposito

GERALDINE ESPOSITO,
Councilwoman

Charles A. Lefkowitz

CHARLES A. LEFKOWITZ,
Councilman

Eugene Gerrard

EDWARD J. HENNESSEY,
Councilman

TIMOTHY P. MAZZEI,
Councilman

EUGENE GERRARD,
Councilman

James M. Tullo

James M. Tullo
Councilman

Tesla, a Little-Recognized Genius, Left Mark in Shoreham

By JOHN RATHER

IT'S a safe bet that relatively few people on Long Island have heard of Nikola Tesla, the world-shaking electrical genius whose invention of polyphase alternating current made him, more than anyone, the man who electrified the 20th century.

Even fewer people are likely to know that Tesla did some of his most visionary work in a laboratory built for him in Shoreham exactly a century ago by Stanford White, the Gilded Age architect who was a friend and admirer.

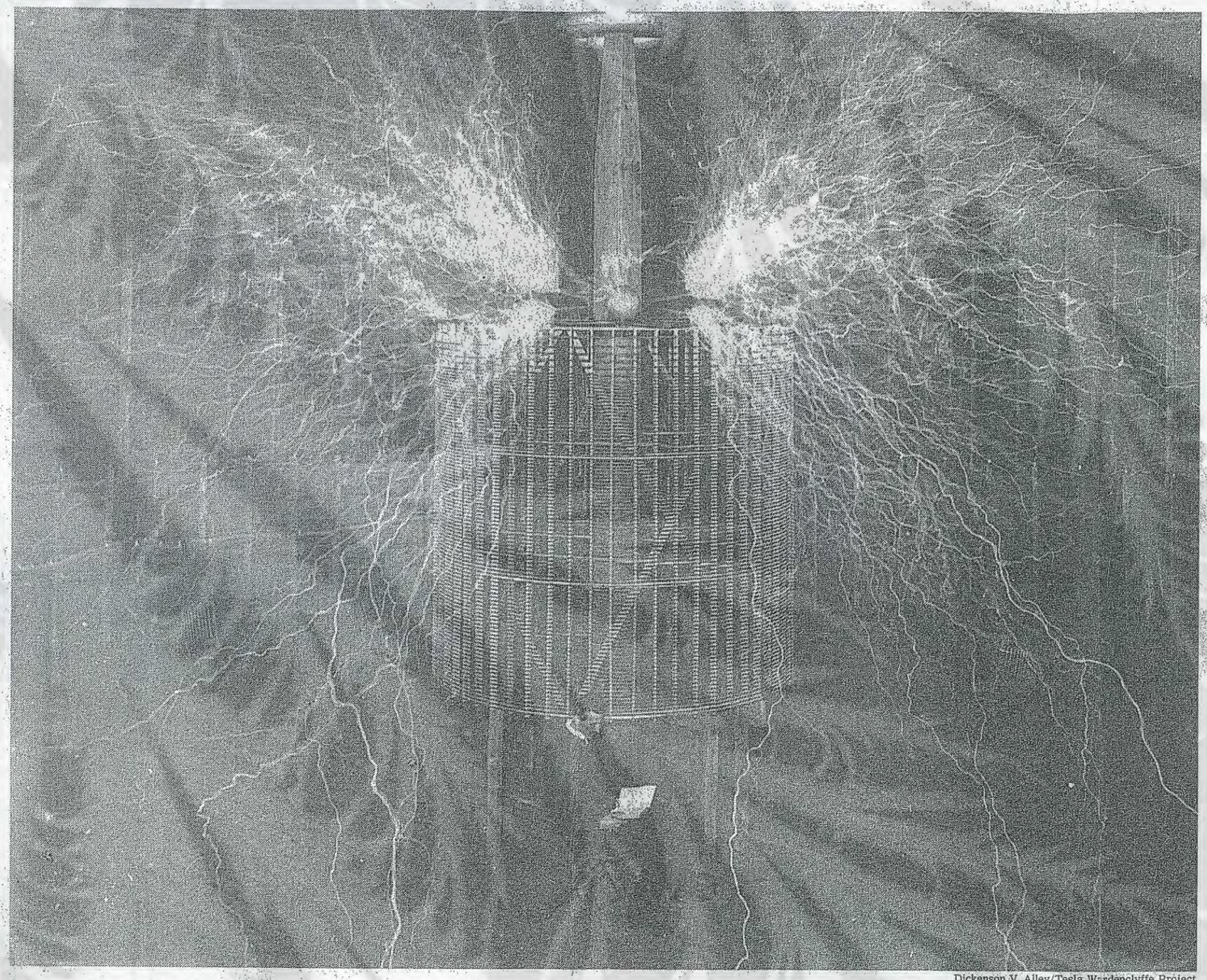
And it would be a surprise to almost everyone that the 94-by-94-foot laboratory, known as Wardenclyffe and envisioned by Tesla as a prototype for a stupendous world communications and wireless electric system, is still standing and in relatively good shape only yards from Route 25A, a major state highway.

Today the laboratory's red-brick facade is barely visible through overgrown foliage from a fence around the 16.2-acre property. The unused site, now owned by Agfa-Gevaert, the Belgian photographic film giant, is closed to the public. It is undergoing a state-ordered cleanup for soil and groundwater contamination linked to Peerless Photo Products, a previous owner that was acquired by Agfa.

A security guard who never heard of Nikola Tesla turned away visitors on a recent afternoon. The property, he said, was unused and sealed shut while the owners decided what to do with it.

Hanging in the balance, Tesla historians and preservationist said, is the fate of the last intact Tesla workplace anywhere in the world and a gem of Long Island history too long left in the rough.

"This is an extremely important landmark," said Barbara Van Liew, an architectural historian from St. James. "By all means, it should be



Dickenson V. Alley/Tesla Wardenclyffe Project

Interior of the Colorado Springs Experimental Station in which Nikola Tesla sits next to the extra coil of his large magnifying transmitter in 1899.

fers on the site, ranging from developers to Tesla-related societies," said the statement by Robert Hoffmann, director of general services and facilities for the Agfa Corporation in Ridgefield Park. But, he added, the property is not now under contract or listed with any broker.

Mr. Hoffmann said that the site was structurally sound and that company officials were aware of its historic significance.

The company declined to support listing it on state and national registers of historic places. Once the property is sold or donated, applying for that designation would be up to the new owner, Mr. Hoffmann said.

As long ago as 1967, the Town of Brookhaven named the laboratory property a historic site. But no formal application has been made for the state designation, a precursor to the federal designation.

James P. Warren, a historic preservation program analyst for the New York State Office of Parks, Recreation and Historic Preservation, said owner consent was usually required for a listing on the state register and always required for the national register. He said the property was eligible for both. Merely being associated with White is significant, he said.

A rival of Edison's without the financial backing.

Wardenclyffe may have been White's last creation. In 1906 he was shot and killed by the jealous husband of a former chorus girl, Evelyn Nesbit, at the original Madison Square Garden, which he designed.

Tesla, born in 1856 in Croatia,

preserved. Tesla invented a lot of the things we use today, and he doesn't get much credit."

In perfecting the alternating-current power system now used around the world, Tesla prevailed over Thomas Edison, who believed in an inferior direct-current system and strove in vain to prove that alternating current was unsafe.

It was Tesla, not Marconi, who invented radio. He also harnessed Niagara Falls for hydropower and invented, among many other things, a bladeless steam turbine, the first remote-controlled torpedoes and devices that had applications in missile defense and computers, long after his death in 1943.

Now the race is on to preserve Tesla's legacy and White's architecture in Shoreham.

Two groups, the Tesla Wardenclyffe Project, a national organization based in Colorado, and Friends of Science East in Shoreham, are hoping to have the site listed on the state and national registers of historic places. Their plans also call for establishing a Nikola Tesla Science Center in the laboratory building, where Tesla memorabilia would be put on display.

The groups are asking Agfa to donate the site to the Town of Brookhaven, where Shoreham is situated, to clear the way for the historic listings and the science center.

But Agfa has been noncommittal, and the standstill is likely to persist until the environmental remediation is complete. The State Department



Tesla Wardenclyffe Project

The Wardenclyffe Laboratory/ Power Plant in Shoreham in 1904

of Environmental Conservation, which is overseeing the cleanup, recently asked for more testing for possible contamination. It is not clear when all work will be done.

"At this point everything is between Agfa and the state," said Gary Peterson, a spokesman for the Tesla Wardenclyffe Project in Breckenridge, Colo. "But Agfa has let us know they are aware of the historic significance of the Wardenclyffe site and that they did not intend to do anything untoward."

Jane Alcorn, the president of Friends of Science East, said a recent study done by Shoreham residents envisioned the Tesla site as a center for the hamlet and a place to teach children about science.

"Not that many towns on Long Island have a Stanford White building," she said. "For that alone it's worth preserving." Charla Bolton of the Society for the Preservation of Long Island Antiquities in Cold Spring Harbor agreed. "There is no question, it is worthy of preservation," she said.

But the groups and others familiar with the property are concerned that Agfa may decide to sell to a developer once the cleanup is over.

The company, which has regional offices in Ridgefield Park, N.J., said in a statement that it would consider all options. "Agfa has had many of-



Maxine Hicks

The Tesla laboratory site in 1997; preservationists are urging the owner to donate it to Brookhaven.

lived in Manhattan hotels for most of his life. He was already an acclaimed inventor when he arrived in Shoreham in 1902. He was fleeing Manhattan, where his celebrity had begun to interfere with work in his laboratory on Houston Street, for the solitude of the Long Island countryside. The new laboratory was financed with $150,000 from J. P. Morgan, who expected to make a fortune on Tesla's work.

Somewhere in the undergrowth at the Shoreham site are remnants of the concrete footings for the 187-foot radio and electrical transmission tower that a White associate, J. D. Crow, erected for Tesla in 1903.

The octagonal wood-frame tower, perched over a 120-foot underground shaft, was the core of a generating system designed to use the earth and the upper reaches of the atmosphere as conductors of electrical impulses that would reach around the globe.

From 1903 until it was razed in 1917, the never-quite-completed tower rose like a giant mushroom over eastern Long Island and could be seen from across the Sound in Connecticut.

Tesla's experiments faltered when Morgan declined to invest more money. Tesla struggled on, mortgaging the property to raise cash. But by 1915 he was out of money, and the property went into foreclosure. He remained convinced that success had been at hand. It is a simple feat of scientific electrical engineering, only expensive, he wrote. Blind, faint-hearted, doubting world.

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Trip to Belgrade and Serbia, September 9 through 30, 2002

Society Executive Secretary, William Terbo, spent 22 days in Yugoslavia (Serbia) of which five full days were spent in Belgrade (plus two days involved in arrival and departure). The better part of two days was spent in meetings and events at the Nikola Tesla Museum (Muzej Nikole Tesle) in Belgrade, and with Director, Mme Marija Sesic.

On Tuesday, September 17th, William and Boyana Terbo placed a large floral display at the foot of the pedestal on which is placed the golden sphere holding the ashes of Nikola Tesla. The pedestal and sphere are located in a place of honor, a draped and paneled large alcove, in a quiet area of the first floor of the Museum. The ribbon attached to the floral display read in part "Your Family Remembers You and the World Remembers You". A video and photographs were made of the presentation for press, family and Society archives.

The Nikola Tesla Museum is a popular destination for school class field trips. The Museum provides professional tour presentations for these groups. Every day several classes visit the Museum to absorb something of the presence of this icon through his personal effects, to participate in demonstrations of the Tesla Coil, the robot boat and other exhibits, and to see the honors given Tesla from around the world. While at the Museum, to the delight of their teachers, Mr. Terbo took time to interact with a 5th Grade (11 and 12 year olds) History class and, later, with a 6th Grade combined Physics and English classes. The children were enthusiastic and asked many thoughtful and serious questions both about Tesla and Mr. Terbo. Each group insisted on individual autographs and each teacher requested a written paragraph to bring back to school as a reminder of the visit. This contact was very special for both the students and Mr. Terbo.

This year represents the 50th year that the Museum has been open to the public. The principal founder of the Museum was Dr. Sava Kosanovic, nephew of Nikola Tesla and former Yugoslav Ambassador to the United States and the United Nations. Mr. Terbo's father, Nicholas Trbojevich, and Dr. Kosanovic were very close in several ways: close in age, as first cousins raised nearby, and both went away to University in Budapest. (Society Executive Board member Charlotte Muzar was secretary to Dr. Kosanovic both in New York at the time of Tesla's death and later in Washington during his tenure as Ambassador.) Mr. Terbo had ample time to meet and talk to Dr. Kosanovic on his visits to Detroit during his time in the U.S. in the late 1940's and early 1950's.

Later on September 17th, William and Boyana Terbo placed a large bouquet on Dr. Kosanovic's memorial at the Belgrade Central Cemetery. The memorial is prominently located on the right-hand side of the central walkway about 50 meters from the Cemetery Grand Entrance. Photos were taken for family and Society archives.







NIKOLA TESLA MUSEUM, BELGRADE

SEPTEMBER 17, 2002

PRESENTATION OF FLORAL DISPLAY AT GOLDEN SPHERE CONTAINING TESLA'S ASHES

WILLIAM H. TERBO, GRANDNEPHEW AND EXECUTIVE SECRETARY, TESLA MEMORIAL SOCIETY, INC.







NIKOLA TESLA MUSEUM, BELGRADE 9/17/2002

- BOYANA TERBO WITH TESLA URN AND FLORAL DISPLAY
- WILLIAM TERBO INTERACTING WITH VISITING BELGRADE 5TH GRADE SCIENCE STUDENTS







BELGRADE, SEPTEMBER 17, 2002

PRESENTING FLOWERS AT GRAVE AND MONUMENT OF DR. SAVA KOSANOVIĆ, FOUNDER OF THE NIKOLA TESLA MUSEUM

BY WILLIAM H. TERBO, NEPHEW (COUSIN)
EXECUTIVE SECRETARY, TESLA MEMORIAL SOCIETY

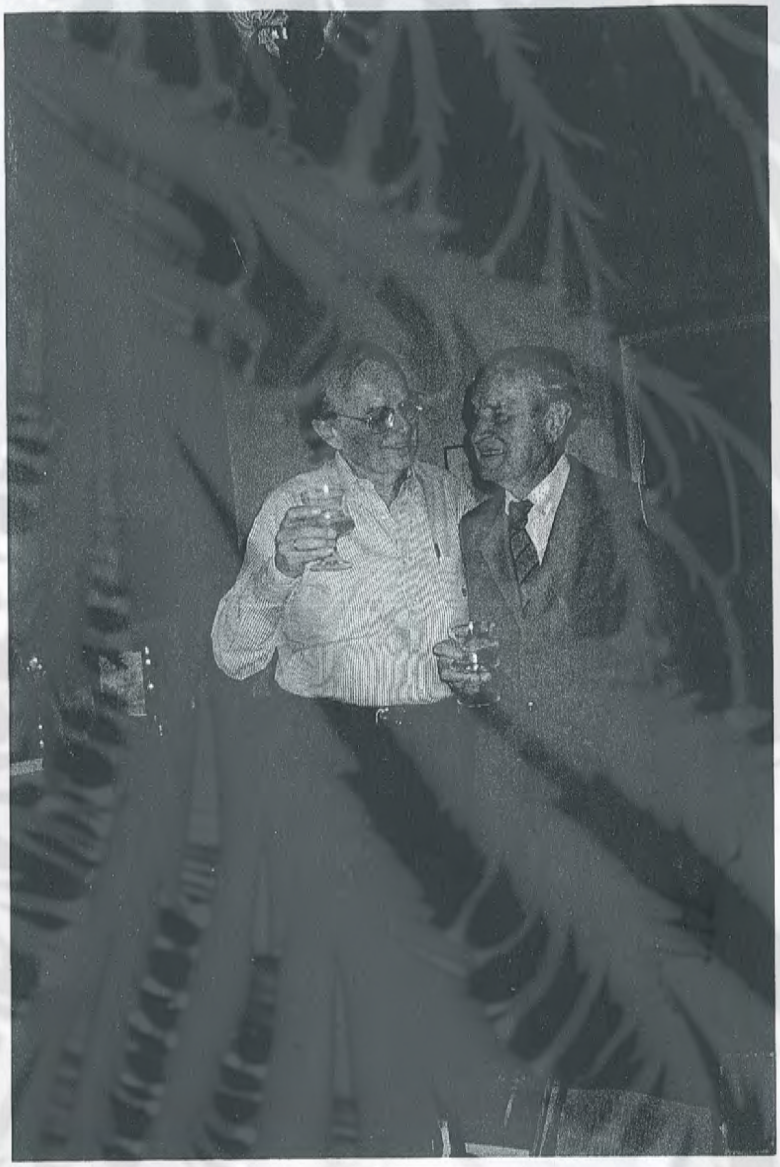


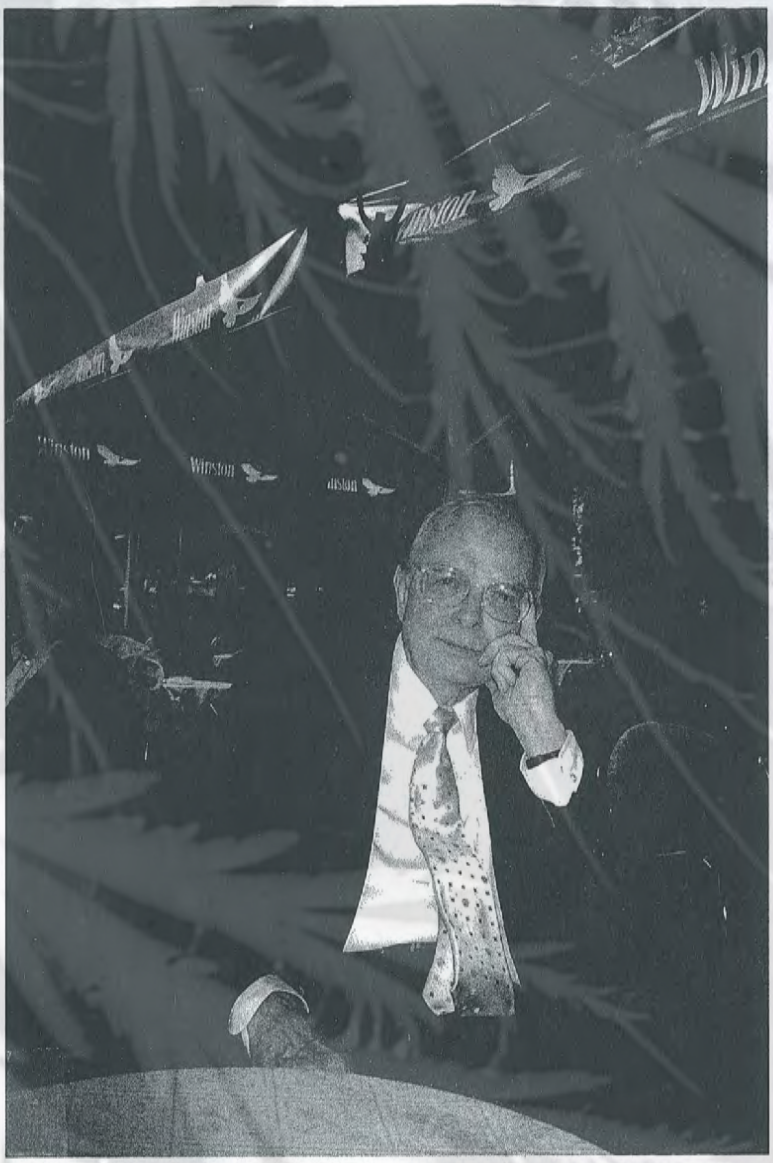




NIKOLA TESLA MUSEUM, BELGRADE 9/17/2002

- BOYANA TERBO WITH TESLA URN AND FLORAL DISPLAY
- WILLIAM TERBO INTERACTING WITH VISITING BELGRADE 5TH GRADE SCIENCE STUDENTS







SEPTEMBER, 2002

WILLIAM TERBO WITH:

- VASA PERENDIJA (90-YEAR OLD ASSOCIATE OF DR SAVA KOSANOVIĆ IN 1940's & 1950's
- AT HOTEL MOSKVA BELGRADE (WAITING FOR FLORAL DISPLAY)
- DUSAN TRBOJEVIĆ COUSIN AND FAMOUS CONCERT PIANIST (RESTAURANT DAČO)



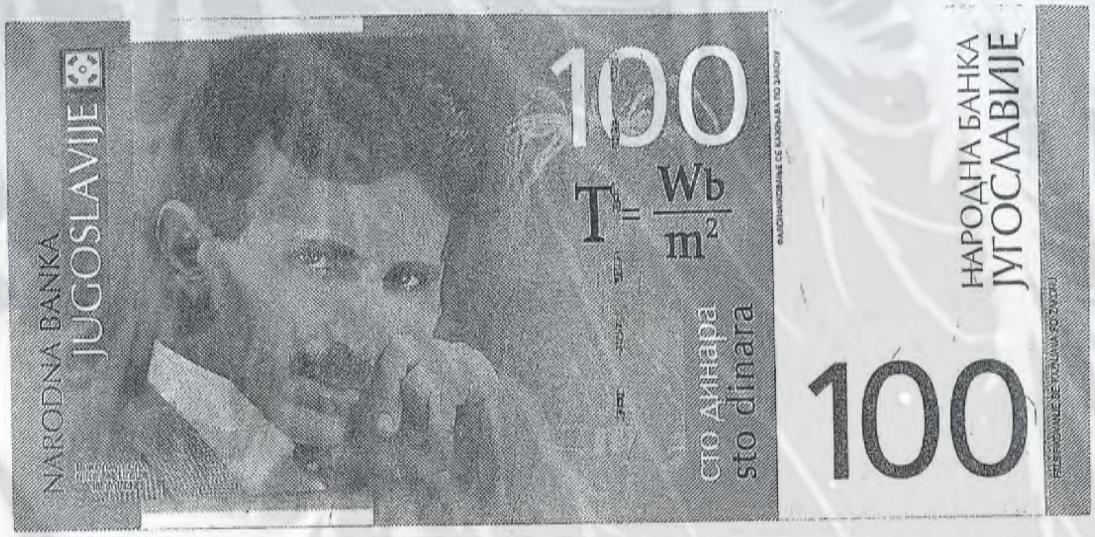




BELGRADE, SEPTEMBER 17, 2002

PRESENTING FLOWERS AT GRAVE AND MONUMENT OF DR. SAVA KOSANOVIĆ, FOUNDER OF THE NIKOLA TESLA MUSEUM

BY WILLIAM H. TERBO, NEPHEW (COUSIN)
EXECUTIVE SECRETARY, TESLA MEMORIAL SOCIETY


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1868 · МИХАЈЛО ПЕТРОВИЋ · 1943
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1893 · МИЛОШ ЦРЊАНСКИ · 1977
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1856 · НИКОЛА ТЕСЛА · 1943
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1868 · АЛЕКСА ШАНТИЋ · 1924
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ПТТ
ЈУГОСЛАВИЈА

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076

A&E Biography Program To Honor Inventors

The Arts & Entertainment Television Networks is preparing a number of *A&E Biography 15th Anniversary Special* video programs to recognize the various subject categories of the series. One Special is being prepared to honor "The 15 Most Important Inventors and Inventions of the Twentieth Century." Broadcast is scheduled to air in the fall of 2002, to coincide with the Biography program's anniversary year.

The 15 Inventors and Inventions honored are (in alphabetical order by inventor/s):

- Leo Baekeland: Plastics (Bakelite), 1907
- Tim Berners-Lee: World Wide Web
- Herbert Boyer & Stanley Cohen: Medical Genetic Engineering, 1986
- Thomas Edison: Various (Phonograph, Motion Picture Camera)
- Philo Farnsworth: Electronic Television, 1927
- Henry Ford: Assembly Line
- Gordon Gould: Laser
- Guglielmo Marconi: Radio Signals
- Gregory Pincus: Birth Control Pill (Oral Contraceptive), 1954
- Jonas Salk: Polio Vaccine, 1955
- William Shockley, John Bardeen & Walter Brattain: Transistor, 1947
- Leo Szilard: Chain Nuclear Reaction, 1942
- Nikola Tesla: Various (Tesla Coil, Radio Tuned Circuits, Remote Control)
- Alan Turing: Programmable Computer
- Orville & Wilbur Wright: Airplane (With Motor), 1903

(The specific inventions to be associated with each inventor/s will be defined when the program is aired.)

William H. Terbo, Executive Secretary of the Tesla Memorial Society and grandnephew of Nikola Tesla provided the on-camera interview for the Tesla segment. Personal, Society and Tesla Museum photographs are to be presented as a part of the segment.

It is a testament to the breadth of Tesla's inventive genius that he be included among the greatest of the Twentieth Century. The greater part of Tesla's fame is usually associated with his Alternating Current Discoveries. Even Tesla's most important his radio patents predate the turn of the Century. (A fact that defeated Marconi's claim for radio patents.) Tesla's vision was so advanced that work done a century ago still bears fruit and adds to his current reputation.

WHT/tmsna(3)

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Trip to Sydney Australia, August 29 through September 8, 2002

Society Executive Secretary, William Terbo, was invited as a guest and to speak at the St. Lazarus Serbian Orthodox Church *6th Annual Ball* held on Saturday, August 31st in the Ball Room of the Australian Technology Park, Sydney Australia. **Commemorating Nikola Tesla** was the theme of the Ball and Mr. Terbo, as one of the two remaining closest living relatives of Nikola Tesla, was the featured speaker. While Nikola Tesla holds a place of high honor among all elements of world scientific, academic and cultural societies, his Serbian ethnicity earns him the highest esteem among world Serbs.

Over 250 attended the Ball. The Parish Priest, Fr. Miodrag Perich, and the President of the Parish Board, Mr. Petar Kozlina, also made brief remarks. Musical entertainment, traditional dancing, dinner and dancing completed the Program. Mr. Terbo greeted as many of the guests individually as time would allow during the Ball. Many additional contacts were made at subsequent meetings and dinners. This provided the opportunity to see a bit of Sydney and meet the Australian people.

Mr. Terbo and the Tesla Memorial Society thank the hosts for their most excellent friendship and hospitality.

The Society presented complimentary copies of the new biography *Tesla: Master of Lightning* and two of the Society's most popular videos (PAL format, the European and Australian video standard) as well as several other Society items for distribution and to be used in the Church Library.

Mr. Terbo acquired several video items in Sydney including a copy of the 1992 Yugoslav network TV program (PAL format, Serbian language) commemorating the centenary of Tesla's 1892 visit to Belgrade. Also received were a Tesla CD produced by the Church and the Diocese for distribution at the Ball and a very interesting new (1999) British Tesla biography *The Man Who Invented The Twentieth Century* by Robert Lomas.

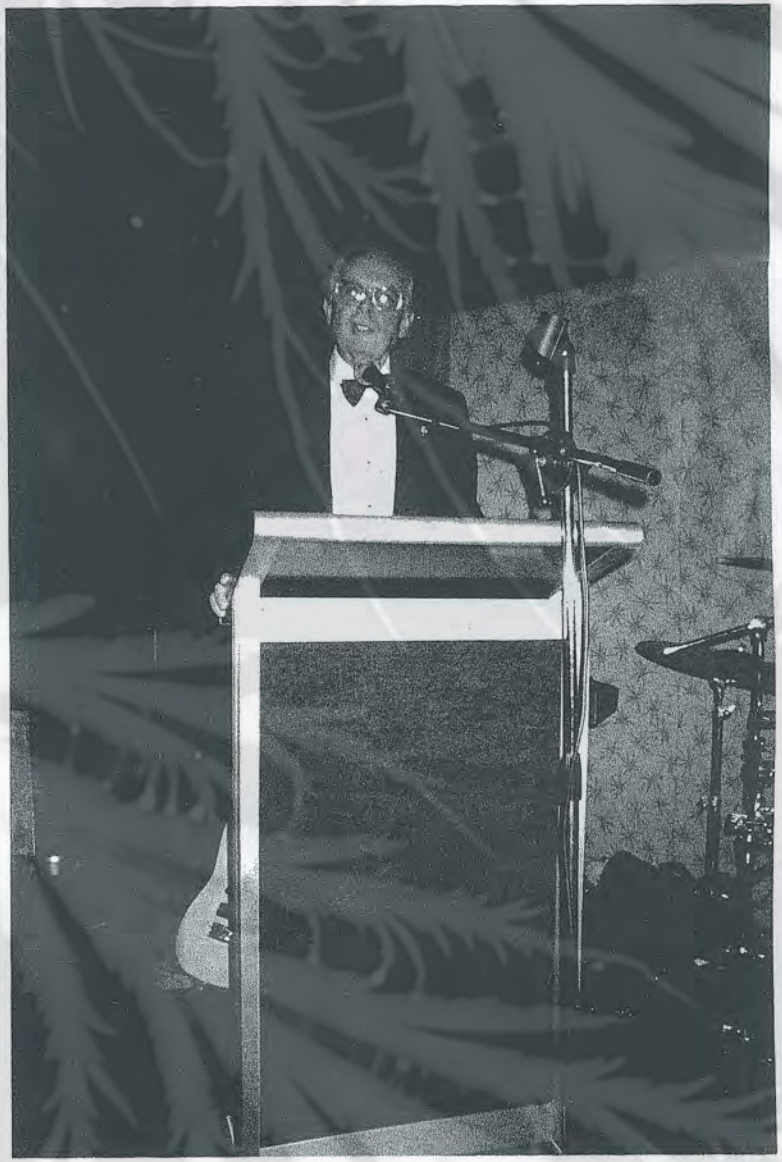
Mr. Terbo gave interviews to local and Australian media. Preliminary planning has begun on a cooperative arrangement between the Society and interested Australians to form an associated Chapter of the Tesla Memorial Society serving Australia and New Zealand.

On Sunday, September 8th, Mr. Terbo departed Sydney and continued to Belgrade.

TMSot







SYDNEY, AUSTRALIA 8/29 - 9/8/2002

- ARRIVAL DINNER WITH HOSTS: FATHER PERICH & PETAR KOZLINA (BLUE SHIRT)
- REMARKS AT ST. LAZARUS 67TH ANNUAL BALL
- MR. TERBO & SYDNEY SKYLINE

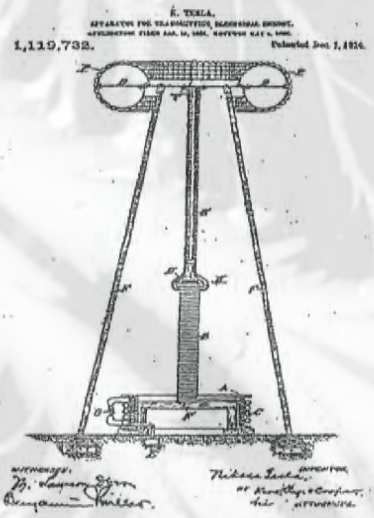
AMERICAN CLUB
SYDNEY 9/4/2002

ABOVE:
NADA RADIMIR
& WILLIAM TERBO

LEFT
ANA DELEON,
WILLIAM TERBO,
NADA RADIMIR
(HOSTESS)
PETAR KOZLINA

PRESENTS

"ROOM 207: NIKOLA TESLA"



Writer: Paul Brown
Director/ composer and sound design: Max Lyandvert
Installation and costumes: Feruu Seljuk
Lighting Design: Allan Hirons

Performers:
Thor Blomfield – Nikola Tesla
Brian Carbee – Mark Twain, J. Pierpont Morgan, Robert McMahon, the Engineer
John Noble – Thomas Edison, Robert Underwood Johnson, Willis Strauss, the Physicist
Felicity Price – Djouka Tesla, Katherine Johnson, Nicole Sharpe
Helmut Bakaitis (the Architect) – Voice of Nikola Tesla

Production/Stage Manager: Sharna Galvin
Electrical Experiments: Robert McMahon (Australian Technical Industries)
Sound: Jeremy Silver
Video Production: Tim Elston
Publicity: Brian Keogh
Poster Design: Katerina Stratos
Video Recording: Toby Oliver, Cineartimage

CREATIVE DEVELOPMENT
Patrick Nolan, Thor Blomfield, Paul Brown, Max Lyandvert, Felicity Price, Gabriela Tylesova, Mark Kilmurry, Andrew McDonald

SCENE LIST

PROLOGUE:	The Museum/Hotel
SCENE 1:	The Field of Dreams
INTERLUDE:	Robert and Willis
SCENE 2:	Tesla and His Mother
SCENE 3:	America, Tesla and Edison
INTERLUDE:	A Scientist and an Engineer
SCENE 4:	My Inventions

INTERVAL

SCENE 5:	Three Friends: Tesla and the Johnsons
INTERLUDE:	Building Wardenclyffe
SCENE 6:	J. Pierpont Morgan
SCENE 7:	Death
INTERLUDE:	Rebirth: Nicole Sharpe
EPILOGUE:	Tesla's Coil

Characters

Nikola Tesla: The inventor of Alternating Current power systems, radio, X-rays etc; Serbian who migrated to America and lived among New York high society.

Djouka Tesla : Nikola's mother. An inventor in her own right, from the Serbian village of Smiljan.

Thomas Edison: American inventor of the electric light bulb, of electricity supply systems, and arguably of moving pictures; champion of Direct Current systems. Gave Tesla his first job in America.

J. Pierpont Morgan: Famous New York banker and philanthropist at the turn of the Twentieth Century; funded Tesla's work until the Wardenclyffe project got out of hand.

Robert Underwood Johnson: Publisher of Century Magazine, who became Tesla's friend, and published several of Tesla's visionary writings.

Katherine Johnson: Robert's wife and lifelong friend of Tesla. Professed to be in love with the inventor.

Mark Twain: the famous author, who visited Tesla's laboratory in New York.

A 'Guide': A voice, and a projected image that could be what remains of Tesla himself.

Modern Day Engineers/Witnesses

Robert McMahon: An electrical engineer working in suburban Sydney to recreate Tesla's experiments. Has built his own Tesla Coil, now building a working model of Wardenclyffe.

Willis Strauss: A consulting electrical engineer and inventor; assisting Robert with his experiments; one time member of the Australian Tesla Club.

A Physicist: retired scientist who worked on electrical systems and instruments in the post war period.

An Engineer: Electrical inventor working in the post war period, who helped build several important electrical inventions.

Nicole Sharpe: High School student, electrical systems inventor, and winner of a national competition for sustainable design.

Sources:

The 'Tesla voiceover' is derived from Nikola Tesla's own writings, in one scene from letters between Tesla and Katharine Johnson, and in another scene letters between Tesla and J. Pierpont Morgan. The main sources are:

'My Inventions' by Nikola Tesla in *Electrical Experimenter*, 1919

'The Problem of Increasing Human Energy' by Nikola Tesla in *Century* magazine, June 1900

We also acknowledge the invaluable background material derived from:

Tesla Man out of Time, by Margaret Cheney 1981

The Man who invented the Twentieth Century: Nikola Tesla, Forgotten Genius of Electricity, by Robert Lomas 1999

Prodigal Genius: The Life of Nikola Tesla, by John O'Neill 1968

'Nikola Tesla', article in *Science* magazine, by Kenneth Swezey May 1958

NIKOLA TESLA

Nikola Tesla, born in 1856, was a Serbian electrical engineer and physicist who, in the West, remains relatively unknown despite being responsible for some of the most influential inventions in the history of modern technology. His story plumbs many of the great themes of human existence: genius, success, fame, sexual desire, obsession, truth, love and grief.

Migrating to America as the Twentieth Century was about to dawn, Tesla developed a way of harnessing Alternating Current, to create a form of 'polyphase' electrical power which still turns the wheels of industry and domestic life. He also invented radio before Marconi, as recognized in the US High Court in 1943. Tesla arguably developed the keys to modern communication technology, and he conceptualized long range weaponry that was ultimately perverted into Ronald Reagan's Star Wars program.

And why is Tesla largely unknown in the West? Was it because of his personality, or because he was an 'alien' in American society? Was it because of his inventions, or was it what he had to say about humanity? His proposals for free transmission of electrical power cut against the commercialization of technology which characterized the Twentieth Century; and Tesla's plans made him an outcast amongst bankers and industrialists.

Philosopher, poet, showman and spiritualist, it seems Tesla made his mark as an intellectual and theoretical thinker in an era when the character and role of 'science' was in great flux. Thomas Edison, famous for Direct Current electrical systems by the time Tesla reached America, was constructed as an 'empirical' scientist using a trial and error approach. Tesla in contrast relied on imagination and theoretical calculation. Both men used the popular press and public presentation, even spectacle, to communicate their knowledge, prompting backlash from researchers wanting to 'purify' science as a knowledge making enterprise governed by norms and institutionalized through scholarly journals and associations. Ultimately Tesla fell foul of such fraternity as his ideas and inventions seemed to become more fanciful and even heretical in his later life.

Despite his extraordinary (even terrifying) accomplishments Tesla was largely forgotten in both the eyes of the public and in scientific circles and ended his life destitute, lonely, and under FBI scrutiny. He died alone in his New York hotel room in 1943.

The play in context

This is a particularly relevant time for such a play to be developed. How optimistic can we remain about a century charged with electricity? In the modern world, electricity and the equipment it powers have become autonomous forms of life – out of control and as self perpetuating as the human race itself, yet unsustainable and in need of system overhaul.

Technological change is rapid and seemingly unstoppable. In Australia, issues such as our energy options, the National Electricity Grid, and rapidly expanding communications technology have vast implications for the way in which we lead our lives, and yet many of us know very little about them. Nor do we know how to control such developments.

Our production takes key moments in Tesla's life and links these to the way in which the Twentieth Century has exploited technology to both enhance and potentially undermine the fabric of our society.

Artscience and Knowledge

The methods used by the Arts and the Sciences are sometimes thought to be vastly different. But in both areas of endeavour, knowledge about the world is built from observation and experimentation. This knowledge-making potential suggests that the integrated use of 'artscience' might make for better decisions about 'what then must we do' (eg. about social and population issues, about environmental crisis, about putting an end to war).

Certainly in our show we want to make art by performing science, just as we want to explain science by performing art. The project combines scientific experiments with contemporary physical theatre and installation art, and in doing this we recognize that science can provide fresh metaphors and new language to explore narratives, characters and themes. Coming from the other direction, we can say that our show will enhance the public understanding of science, for example through portrayal on stage of experiments and by exploring through story the 'cultural embeddedness' and social history of particular technologies.

But beyond this (and some might call our show 'transdisciplinary') we want to create some new hybrid knowledge through the relationship between cast, crew and audience. In the case of **Room 207 Nikola Tesla**, the knowledge is about energy systems and our choice of energy technologies, relevant to decisions about the kind of future we all might desire. We depict the life of one man, Nikola Tesla, inventor of Alternating Current and therefore of our taken-for-granted electrical systems. But in some ways we also present an entire century, the story of electrical power and energy use - in fact a tale and a commentary on the whole modernist way of life, and on today's attempts to reform energy systems to make them sustainable.

Basic Explanation of the operation of a Tesla High Voltage Transformer

The Tesla high voltage generator is a radio frequency transformer comprising a primary winding of a few turns magnetically coupled to a secondary coil having many turns.

The secondary coil, together with the top electrode, forms a radio frequency resonant circuit. The primary coil, with associated high voltage capacitor, is tuned to be in resonance with it. The coupling between the two coils is optimized.

The capacitor, charged to a high voltage, discharges into the primary through a spark gap. This results in a powerful radio frequency current oscillation in the primary circuit. This in turn induces an extremely large radio frequency voltage in the secondary winding to produce a spectacular electrical breakdown from the top electrode.

THANKYOUS
Miles Van Dorsen, Patricia Chriss, Gavin Wild, Rob Largent, Stephanie Ridgeway, Joey Ruigrok, Vicki Bamford, David Miller, Gavin Robbins, Kent Blackmore, The Amazing Otto Butkus, Lee Wilson, Iain McGill, Hugh Outhred, Ted Spooner, Trevor Blackburn, Robert McMahon, Willis Strauss, Nicole Sharpe, Mark Mitchell, Lee Wegner, Kaira Hachefa, Company B, Sydney Theatre Company, NIDA, ATYP, Griffen Theatre

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TESLA MEMORIAL SOCIETY, INC.
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May/November 2002

Addition and update to Society "Recent Events and Activities" dated April 2002. For additional detail on the following items, visit our website or contact the Society directly.

In Memoriam: Daniel M. Dumych

The Society regrets to announce the premature passing of Honorary Director Daniel Dumych, Tesla biographer and Niagara Falls, New York, tourism activist. Using the advantage of living and working in the area, his research uncovered many new, or previously overlooked, facets on the history of the harnessing of the power of Niagara Falls. The revolution of the introduction of alternating current power, based on the patents of Nikola Tesla and brought to realization by Tesla and George Westinghouse, was a prominent focus of his several authoritative published works. Mr. Dumych produced *Nikola Tesla – The Inventor Who Changed the World* published by the Niagara Falls Convention & Visitors Bureau. He also wrote *Nikola Tesla and The Development of Electrical Power at Niagara Falls* as a part of the Educational Curriculum Kit distributed to the nearly 500 High Schools in the serving area of the Niagara Mohawk Power Corporation. This distribution was in connection with the Centennial Celebration *Century of Electrical Energy, November 15, 1996* sponsored by Niagara Mohawk, Westinghouse Electric, General Electric and the New York Power Authority. The Society expresses our most sincere condolences to his mother, Ann.

Auction of Letters and Memorabilia

Society Executive Board member Leland Anderson amassed the largest collection of Tesla memorabilia, correspondence, photos and equipment in private hands. Mr. Anderson is a noted researcher, writer and lecturer on Tesla and Tesla technology. The collection was accumulated over a period of more than 50 years. Over the past five years, Mr. Anderson has been distributing different parts of his collection to various institutions and organizations to be used for research and display. Now the final portion, original correspondence in manuscript form, is to be offered at auction in the near future by the Swann Galleries in Manhattan. Details concerning the auction will be transmitted as soon as available.

John Wagner Honored at Annual Telluride Tech Festival

Society Executive Board member Mr. John W. Wagner was one of five honored at the Third Annual Telluride Tech Festival held in August in Telluride, Colorado. The Festivals are organized to celebrate the past, present and future of technology. Mr. Wagner was recognized for his efforts of 20 years in creating a program that awards bronze busts of Tesla to leading American Universities. By ensuring that the busts be placed in important and appropriate University locations, they serve as a permanent memorial and a constant reminder of Tesla's eminence in electrical science. Honored with Mr. Wagner were: Murray Gell-Mann, Nobel laureate who identified the Quark;

Vinton Cerf, Internet pioneer; Tim Berners-Lee, originator of the World Wide Web; and Alan Kay, computer pioneer.

Nikola Tesla was among those honored at the First Telluride Tech Festival in 2000. One of the first commercial applications of Tesla technology was the 1891 construction of a conveniently located AC power plant supplying electric power by wire to an area gold and silver mine too remote for DC power. Availability of on site electric power transformed the efficiency of early Colorado mining. Tesla grandnephew William Terbo represented the family and the Society and spoke at the 2000 event.

University of Illinois Receives Bust of Tesla

The University of Illinois is the ninth prominent University to receive a bronze bust of Tesla. Society Executive Board member Mr. John W. Wagner is the founder and guiding light of the Tesla Bust program. In early September, Mr. Wagner and Society Executive Board member, Wallace Edward Brand, were joined by senior UI faculty, staff and students at the Installation Ceremony held in the UI Electrical Engineering Building in Champaign-Urbana, Illinois. Illinois joins Harvard, Yale, Princeton, MIT, CalTech and the Universities of Michigan, Wisconsin and Maryland as recipients of Tesla busts. Purdue University is scheduled to receive a Tesla bust later this year.

Tesla Bust Program

Executive Board member John Wagner has been negotiating placement of Tesla busts at America's most prominent Universities since the first bust was created in 1988. The busts are cast in bronze with black granite bases and bronze plaques. The bust image is that of a middle-aged Tesla about 90% life size. The plaque reads in part *NIKOLA TESLA, 1856-1943, HIS NAME MARKS AN EPOCH.* The bust and base weigh about 250 pounds. By necessity, the bust must be of the highest quality in both artistic representation and in material detail. Anything less would not be appropriate for presentation to the prestige institutions where they are displayed in honored settings. (A typical installation is that of Harvard. Located in the Physics Library of the Jefferson Physics Building, the bust and base are placed on a specially constructed shelf illuminated by a spotlight shining at all times.)

Each bust and base cost several thousand dollars. Some funds are raised through contributions, but most is generated through the sale of six-color Tesla T-shirts, thousands of them. **The Society strongly invites correspondents to participate in the Tesla Bust Program either through donations or through the purchase of T-shirts.** You can reach Mr. Wagner by surfing the web, by e-mail *jwwagner@concentric.net* or by contacting the Society directly.

William Terbo Trip to Sydney, Australia

Society Executive Secretary, William Terbo, was invited as a guest and to speak at the St. Lazarus Serbian Orthodox Church 6^{th} *Annual Ball* held on August 31^{st} at the Australian Technology Park, Sydney. *Commemorating Nikola Tesla* was the theme of the Ball and Mr. Terbo, as one of the two closest living relatives of Tesla, was the featured speaker. While Nikola Tesla holds a place of high honor among all elements of world scientific, academic and cultural societies, his Serbian ethnicity earns him the highest esteem among world Serbs.

There is great interest in Tesla throughout Australia. Discussions have begun on the manner of starting an affiliated Chapter of the Society serving all Australians. The structure of the Chapter must meet the objectives and methods of this Society.

William Terbo Trip to Belgrade and Serbia

Mr. Terbo visited Belgrade from September 15th through 19th. The focus of the Belgrade trip was to discuss the several areas of mutual support and assistance, planned and in place, between the Society and the Nikola Tesla Museum. In honor of the Museum's 50th Anniversary, Mr. and Mrs. Terbo placed a large floral display at the foot of the pedestal on which is placed the golden sphere holding the ashes of Nikola Tesla. Later, Mr. and Mrs. Terbo placed a large bouquet at the Belgrade Central Cemetery memorial honoring Dr. Sava Kosanovic, nephew of Tesla, principal founder of the Museum and cousin to Mr. Terbo.

While in Belgrade and elsewhere in Serbia, Mr. Terbo gave several media interviews, discussed planning with Society European Correspondent and Executive Board member, Mr. Momcilo Simic and visited with persons of interest to the Society.

Dan Mrkich European Research Trip

In September, Society Executive Board member Mr. Dan Mrkich traveled to London, Prague, Budapest, Strasbourg and Paris researching his new book *Tesla's European Years*. Mr. Mrkich has completed Part Two *The Family, Childhood and Youth*. Part Two covers the history of the area of Tesla's birth from the 16th Century to the modern era, his family history, his young life and his several returns to the area from his schooling, work and work in America. (Part One *Education and Early Work* is available by order from the Society.) Tesla's fame in Europe is substantially better recognized than it is in North America. (A page from the Prague telephone directory shows 20 firms using the name "Tesla.")

A&E Network Video Presentation Recognizing Inventors

The Arts & Entertainment Television Networks premiered a Special one-hour program *The Top 15 Inventors of the 20th Century* on June 4th. The "Top 15" were selected and ranked through a poll of 250 journalists, inventors and academics as the "most influential inventors of the last 100 years." No list or ranking can satisfy everyone. If the list were to exclude inventions patented before the 20th Century, Thomas Edison (ranked #1) might not have appeared at all. If the inventions were judged specifically on their impact on the 20th Century, it would be impossible to ignore Alexander Graham Bell (not ranked). If inventors were measured by "patented" inventions, Henry Ford (#12) and Tim Berners-Lee (#15) would not make the cut. If the ranking were based on the work of a lifetime, Nikola Tesla would rank at or near the top. If the selection were based only on 20th Century patents, Tesla's ranking (#7) is about right.

Czech Ministry of Education To Produce Nikola Tesla Video

The Czech Republic Ministry of Education has arranged to produce a short video on the life of Tesla. The video is to be shown to Czech students at the High School level to familiarize them with this giant of electrical science who received a substantial part of his higher education in Prague. Just as in the United States, the Ministry had become

aware that very few young students know of Tesla's fundamental contributions to modern society through his seminal work on electricity and radio. Society Executive Secretary William Terbo gave on-camera interviews and guided the Czech video crew to several Manhattan Tesla sites. Society Executive Board member Dan Mrkich provided assistance in scheduling, permits and visas and guided the crew to Niagara Falls sites on both sides of the U.S./Canadian border. The Czech crew visited the Tesla Museum in Belgrade in September. The program is scheduled for completion this winter.

SCI-FI Television Tesla Program

A one-hour segment of the series *In Search Of...* describing some elements of the work of Nikola Tesla was completed in 2001. The *In Search Of ...* series has moved from the Fox Network to the SCI-FI Network. The first airing of a portion of the Tesla segment *The Tesla Death Ray* appeared on Friday, October 4th as a 15-minute part of a 4-part olio to reintroduce the series. The contract production company who produced the Tesla segment for Fox have a total of eight segments completed. Various full-length segments are being aired each Friday. The Society will inform members when an airdate for the full Tesla segment is scheduled.

Join the Tesla Memorial Society, Inc.

The Tesla Memorial Society, Inc., founded in 1979 and incorporated in 1980, is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla, the "Father of Alternating Current."

The Society is a nonprofit, nonpolitical, all volunteer membership organization operating under Section 501 (c) (3) of the Internal Revenue Code. The Society does not employ professional fundraisers. The Society accepts donations, honoraria and other forms of support in meeting its objectives through support and participation in cultural activities, as a source of archival information and as a media resource through lecture and interview presentations. One hundred percent of funds raised are used in the pursuit of Society Charter objectives.

We welcome membership at the following annual levels: Individual, $25 (Overseas, $40); Supporter, $100; Patron, $250; and Benefactor, $1,000. Member participation at these levels is designed to not only cover direct membership costs, but to ensure the continuation of a very cost-effective organization that reflects the members respect for the memory and ideals of Nikola Tesla.

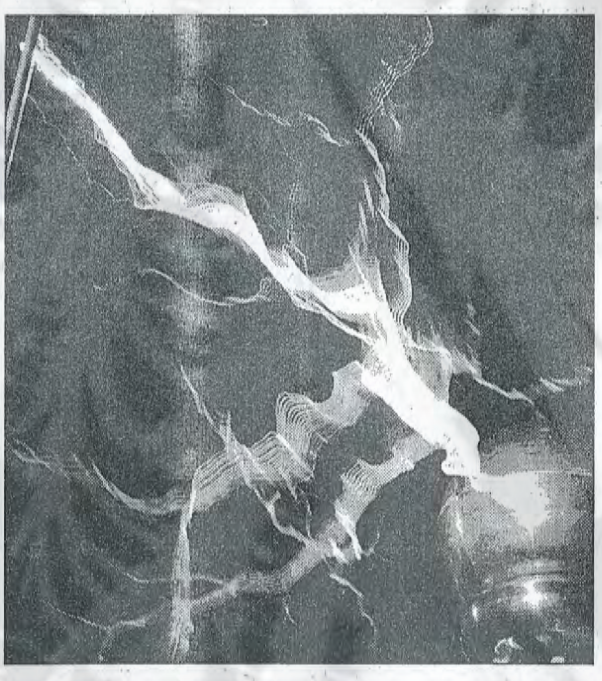
Tesla Memorial Society of New York

Unfortunately, a certain amount of confusion is likely to occur over the similarity in the names of the Tesla Memorial Society, Inc. (the Society) and a new entity, the Tesla Memorial Society of New York (TMSNY). There is no connection between the Society and the TMSNY. The Tesla Memorial Society, Inc. was founded in 1979 and incorporated in 1980 and operates under Section 501 (c) (3) of the Internal Revenue Code. The Society will cooperate with the TMSNY on projects that are serious, appropriate, and well thought out and meet Society goals of honoring and perpetuating the memory of Nikola Tesla in an effective and dignified manner.

TELLURIDE COLORADO DAILY PLANET MONDAY, AUGUST 14, 2000

Tesla's invention revisits town of its birth





A 1.5 million volt magnifier/type Tesla Coil arcs before a crowd of more than 500 spectators on Colorado Avenue Friday night. Several florescent tubes were lit in the hands of spectators due to the 600 volts of electricity passing through their bodies without harm.

Photos by Ben Knight

Tesla Memorial Society, Inc.
William H. Terbo
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Scotch Plains, NJ 07076-3136

NEWARK NJ 1A 0710?
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2004



Mr Jeff Behary
Electrotherapy Museum
2809 NE 15th Street
Pompano Beach, FL 33062

From WILLIAM TERBO 2/4/04

DEAR JEFF:

THANK YOU FOR YOUR RECENT PRELIMINARY PHOTO REPRODUCTIONS (THANKS ALSO FOR NOTES EXPLAINING EACH SEGMENT)

I'VE RECEIVED A (GRATIS) VHS OF YOUR CONFERENCE SPEECH. I HAVEN'T HAD TIME TO REVIEW IT (AS I ALSO RECEIVED GRATIS VHS OF MY SPEECH & THOSE OF THE FORUMS & SETTER.)

I'VE ENCLOSED SOMETHING EXTRA FYI. REGARDS William

Item #PP145 The Drawing Board, Dallas, Texas
© Wheeler Group Inc., 1976

Tesla Memorial Society, Inc.
William H. Terbo
21 Maddaket, Southwyck Vlg.
Scotch Plains, NJ 07076-3136

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Mr. Jeffrey Behary
The Turn Of The Century Electrotherapy Museum
2809 NE 15th Street
Pompano Beach, FL 33062

Presentation to the Board of Directors of the Tesla Memorial Society on May 6, 1990, by Daniel M. Dumych

Less than a mile down Buffalo Avenue from here, the Age of Electricity was born. When William Birch Rankine and Paul Lincoln closed the circuit breakers at 12:01 a.m., November 16, 1896, at the Niagara Falls Power Company's power house, current flashed through the transmission lines from Niagara Falls to Buffalo, where stepdown transformers converted it for use by Buffalo's streetcars. Motormen pushed forward the handles on their controllers, and the trolleys glided into motion, beneficiaries of Niagara's rumbling power. And so, the world was quietly and swiftly changed, irrevocably.

All facets of our modern-day lives are somehow linked with that moment. If this science of electricity were somehow converted to a religion, the powerhouse would be a place of worship, the power tower, its icon.

Unfortunately, we are not so whimsical or poetic a culture, and on the contrary, we need to consciously remind ourselves of the importance of this earth-shaping development nearly a century ago. At least in part to blame is the concept of obsolescence, an equating of the old with the useless, a way of thinking that is deeply ingrained in our culture. While on the one hand it with a certainty propelled our economy forward, it also left a legacy of waste, and a disrespect for the past.

Niagara Falls serves as an ideal example. The hotel in which we now sit was in the early years of this century the site of a meticulously manicured park maintained for the employees of the Shredded Wheat Company. This facility was located across the street from here, and if one is persistent, scattered yellow brick fragments remaining from its demolition can still be found. This factory, at the time of its completion in 1901, was a futuristic model of what a factory should be. Its designers intended it to be a "Palace of Light", which indeed it was, with its 822 large windows. It was air conditioned throughout, and heat was regulated with thermostats. Female workers were provided with free meals; males had to pay a mere ten cents. The facility also

provided 13 bathtubs, 13 shower baths, seven sponge baths and 104 sinks. One must remember that this was done at a time when personal hygiene norms were less exacting than ours. Likewise, the Shredded Wheat Plant was the first factory known to have provided coffee breaks. On breaks, employees were free to make use of the numerous lounges, attend a lecture in the auditorium, or visit the company's circulating library. Now, all that the city has to offer as a reminder of these innovations is an empty parking lot with grass growing through the cracked surface.

In the eyes of our culture, the factory, with the accumulation of years, proportionally lost its worth. Granted that some facilities do over the course of time lose the ability to be productive enough to justify their continued operation, but our culture, in its relentless pursuit of economic efficiency, has forgotten to pay homage to those facilities, to those individuals, who created this world of ours. Only by having artifacts from the past to serve as reminders can we focus our thoughts to appreciate our electro-industrial roots.

The Adams Power Station is another lamentable example of our ingratitude to the past. At the time of its completion in 1896, it was the largest producer of alternating current in the world, and the success of this project provided the impetus the make alternating current the standard means of transmitting electricity the world over. This is where it all started! And what remains now? Power Houses Number One and Two were demolished during the summer and autumn of 1965. Thankfully some local citizens of vision (especially when one considers that this took place during the 1960's, the apex years of the disposable society) had enough foresight to save the stonework of the entranceway of Power House One and reconstruct it as a memorial arch on Goat Island. The site of these two power houses which initiated a revolution is now occupied by a sewage treatment plant. Where generators once whirled unstoppably and banks of marble-paneled circuit breakers stood are now settling pools for sewage. Its mighty hydraulic tunnel, once the largest of its kind in the world, that carried the power house tailrace under the city for nearly a mile and a half now carries processed sewage to the lower river. Rather than leave floral wreaths as a tribute to this historic site, we pour raw sewage on it! Is this the reverence that we have for the past? Has our utilitarian drive for efficiency

killed something deep inside of us? Is something only of worth to us if it can turn a profit? One can't help but wonder if the callous disregard for our common past hasn't played a large part in creating the emptiness that the citizens of the world have been feeling for the past two decades, a void that even our shopping centers, televisions, and credit cards cannot fill.

An opportunity to preserve a significant part of the past is still available to western New Yorkers, if not to anyone else who respects the ~~role~~ part played by Niagara Falls in the development of electricity's role in our lives. The sole remaining building of the Adams Power Complex, the Transformer Building, still provides us with the opportunity to make amends for our disregard of the past. By converting the Transformer Building into a museum, we can preserve a building of immense historical importance and chronical power development in the Niagara Frontier during the years that this area played a leading world role. This would create an opportunity to collect, preserve, and display relevant artifacts before they are lost forever. It would provide us with a living memory of our past, a museum in one of the buildings that played an actual part in making history.

The building is presently off-limits to the public and owned by the Niagara-Mohawk Power Corporation. Two years ago I had the good luck of being able to walk through the building. It is now being used as a storage building for grass-cutting equipment, ceramic pipes, line insulators and other such things. Although the building presently has a less than noble use, it is in very good condition, inside and out. Apparently, since it is still in use, it is maintained regularly. Sadly, none of the original electrical equipment remains. I was told that the transformers were sold to a South American country several years ago, where they are still being used. However, the original overhead crane is still in place. A patent date from 1888 can be seen on it. The size and configuration of the interior make it ideal for being laid out into a museum.

The location of the Transformer Building may prove to be ideal. A large shopping mall is planned for construction north of Buffalo Avenue, and if it should go up, the Transformer Building would find itself in a heavily trafficked area and thus, one would hope, become a place much

visited by both the interested and the idly curious. As one can see on the map I have handed out, it would be a simple matter to link the walkway along the river with the Transformer Building, thus connecting one of Niagara Falls' wonders with its other.

If the Transformer Building does become a museum, it would not be the first such facility that has existed in the area. From 1967 to 1975, the Sir Adam Beck Generating Station No. 1 was home to the Hydro Hall of Memory. Its purpose was to trace the growth of electricity as a force in our lives, and among its displays were early lamps and appliances such as mixers, irons, and toasters, articles which at the time of their manufacture were novelties, in contrast to way in which they are regarded now. Also on exhibit was Canada's first electric motor, which was denounced by a clergyman at the time of its invention as an instrument of the devil, since it would lead to excessive leisure time. A display which tells of the first long-distance transmission of electricity from Niagara Falls to Buffalo describes it as being the beginning of the second industrial revolution. Oddly enough, this museum was never publicized or seen as an attraction in itself, and a drop in attendance caused it to be closed in 1975.

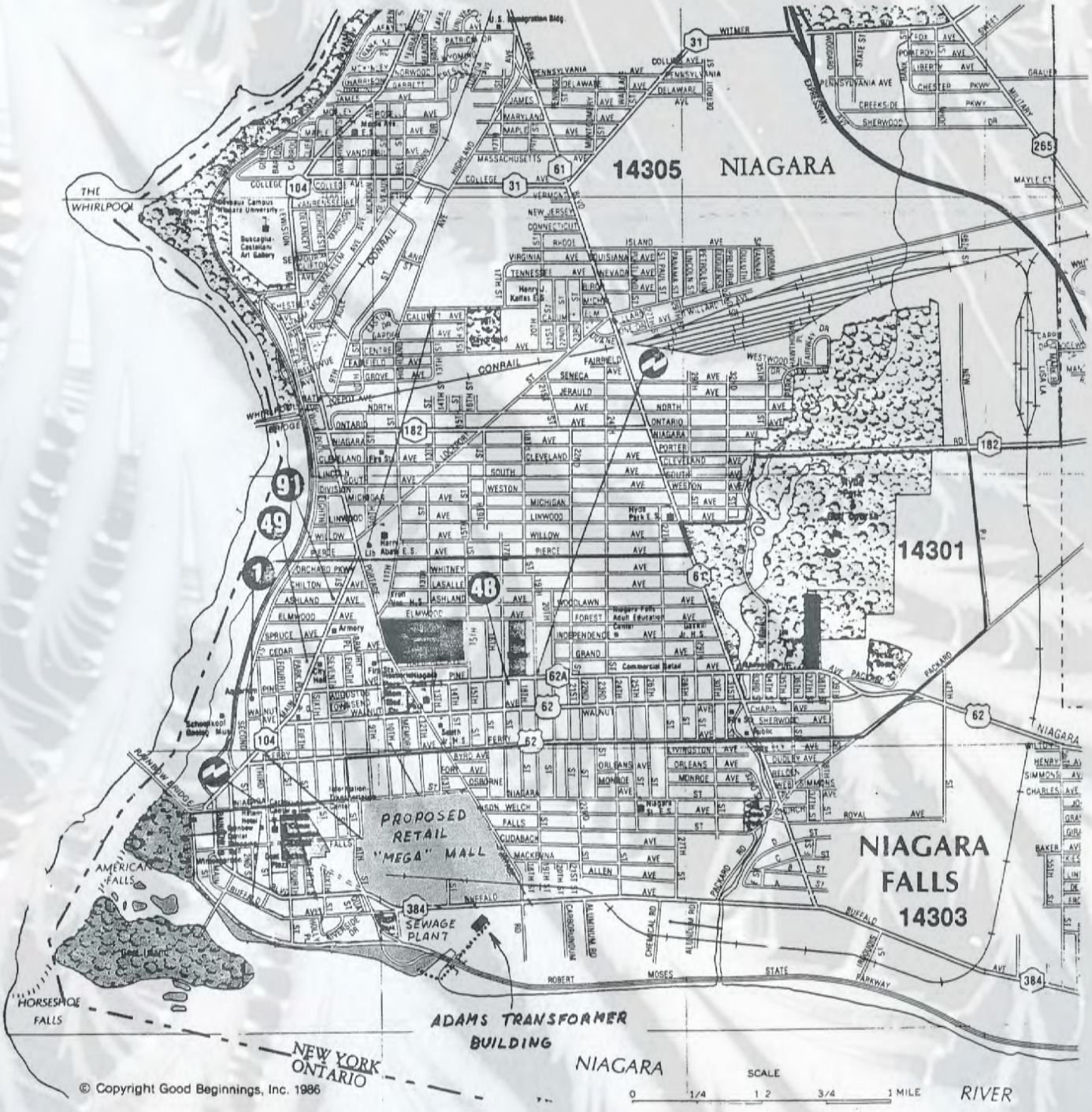
In the summer of 1982, the Sandford Fleming Engineerium was opened in the de-commissioned power house of the Toronto Power Plant, also known as the Electrical Development Company. It failed to re-open the following year because of a lack of funding, and, as in the case of the Hydro Hall of Memory, was minimally publicized. Should the Transformer Building eventually become a power museum, it must avoid the mistake of its two Canadian sisters and make the public aware of its existence.

The two elements that will determine the existence of a museum in the Adams Transformer Building are a) use or possession of the building, and b) funding. It is conceivable that Niagara Mohawk might, as a public relations gesture, either donate or allow unrestricted use of the Transformer Building. If such is not the case, one can hope that they may consider selling it at a "bargain" price. As for funding, it is the opinion of this speaker that the corporations who played a vital role in the funding of the original Niagara Falls Power Company, i.e., the Westinghouse Corporation, General Electric, and ~~Bank~~ House of Morgan be approached for dedicated funding. Since the museum should also describe

the role of the Schoellkopf Power Stations, it would be wise to also approach the Schoellkopf family for advice.

The only right thing for us to do is to pursue establishing a power museum in the Adams Station Transformer Building, and should we fail at that, we must not allow it to fall into disrepair or worse yet, be demolished. We must be its guardians. We should request that the state erect a marker in front of it which explains its historic role. The Transformer Building is all that is left of the history-making Adams Power Station, and it must be preserved in its present form for the coming years, when again the museum concept can be revived. That is the very least that we MUST do. To neglect that duty would be a crime against history and against the future.

A proposal presented by Daniel M. Dumych to the Board of Directors of the Tesla Memorial Society on Sunday, May 6, 1990, to link the Niagara Reservation with the former Adams Transformer Building by means of continuing the river walkway across the remaining portion of the Niagara Falls Power Company intake canal by a bridge, and from that point extending it northeast under the Robert Moses Parkway overpass at the same site, past the Niagara Mohawk switchyards, and on to the former Transformer Building itself.



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Time Catches Up With Tesla's Eccentric Genius

Continued From Page 19

of the Austro-Hungarian Empire, and soon showed a talent for invention and tinkering. In 1884, he took a ship to New York and immediately went to work for Thomas Alva Edison. But the two quickly parted ways after a dispute over an invention.

Going into business for himself, Tesla soon developed the basis for the alternating-current system in worldwide use today. He realized that direct current can be transported over wires for only a few miles, whereas high-voltage alternating current can go on almost forever without sustaining great losses of power. To make the new system practical, he invented and patented a variety of alternating-current generators, transformers and motors.

Edison backed direct current as the perfect electrical source of the future, and the two men fought a heated battle over the best system. It went down in science history as the "war of the currents" — a contest Tesla won.

Conceived Futuristic Devices

So much for Tesla's conventional history. The Centennial Committee says he went on to do much more than just spark the age of electricity — envisioning and inventing a dazzling array of futuristic devices.

"All the literature says Marconi invented the radio," Mr. Grotz said in an interview. "But long before Marconi had a patent, Tesla was demonstrating a radio-controlled model boat and talking about transmitting electrical power across the Atlantic. Compare that to Marconi's S-O-S."

Indeed, in 1943 the Justices of the Supreme Court of the United States overturned Marconi's patent because they found it had been preceded by Tesla's practical achievements in radio transmission.

Another example is radar, which employs short wavelength radio signals that can be reflected back from solid objects. As early as 1900, members of the centennial committee note, Tesla suggested that these wavelengths could be used for locating ships at sea.

Many of the 27 speakers at the Tesla symposium, held this month at The Colorado College in Colorado Springs, put their emphasis on Tesla's most spectacular experiments of all, which occurred at a laboratory not far from the symposium site. There, at the turn of the century, Tesla built enormous coils that generated 10 million to 12 million volts of electricity and sent bolts of artificial lightning flashing 135 feet through the air, a feat that has never been equaled.

Work Shrouded in Mystery

To this day, scientists debate what Tesla accomplished in Colorado, for much of the work was shrouded in mystery. Dr. Robert W. Bass, an electrical engineer with Litton Industries, said at the symposium that one of Tesla's more controversial claims — that he had created ball lightning — was probably true and he cited contemporary theories of physics to explain how Tesla could reproduce such a rare natural phenomonon.

Tesla's laboratory in Colorado Springs was a barn-like structure that sat atop a hill on the prairie and was crowned by an 80-foot tower and beyond that a 122-foot mast. The tall fence surrounding it carried signs reading: "Keep Out — Great Danger." The claps of thunder from his bolts of artificial lightning could be heard for miles.

According to Charles Wright, a retired engineer formerly with the Public Service Company of Colorado, the laboratory was filled with a host of inventions including high-voltage transformers, dynamos, coils, capacitor-discharge devices, oil-insulated capacitors and a large metered control panel.

In Colorado Tesla hit upon what he thought was a revolutionary way to send electricity through the air. "Not only was it practicable to send telegraphic messages to any distance without wires," he wrote of the insight, "but also to impress upon the entire globe the faint modulations of the human voice, far more still, to transmit power, in unlimited amounts, to any terrestrial distance and almost without any loss."

Financed by J. P. Morgan

With the financial backing of J. P. Morgan, Tesla embarked upon a plan to commercialize the discovery, building a 200-foot tower at Shoreham on Long Island. By 1905, however, Morgan had abandoned the project and the tower was never completed.

Tesla, especially in later years, was a man of extraordinary idiosyncrasies and boastful declarations that sometimes sent his science peers into a rage. His ideas for power transmission through air were dismissed by many as pure fantasy.

With a pocket-size vibrator, he once told reporters, he could generate resonant tremors that would split the earth in two. He gave its resonant frequency as one hour and 49 minutes. Whatever the plausibility of his earth-splitting scheme, the rather precise estimate of the earth's frequency turned out to be close to the mark, as was demonstrated during the great Chilean earthquake of 1960, when geophysicists were able to measure the time it took waves to travel back and forth through the Earth.

At the symposium some of Tesla's advocates seemed to try to outdo the master's knack for hyperbole as they conjured visions of death rays and futuristic weapons. In a paper entitled "Star Wars Now!" Thomas E. Bearden, a retired nuclear engineer and Army war games analyst, noted what he said were a number of designs for making weapons based on Tesla's more exotic ideas. The hypothetical devices included what he termed a Tesla howitzer and a Tesla shield that could allegedly stop Soviet missiles.

Proposed Death Rays

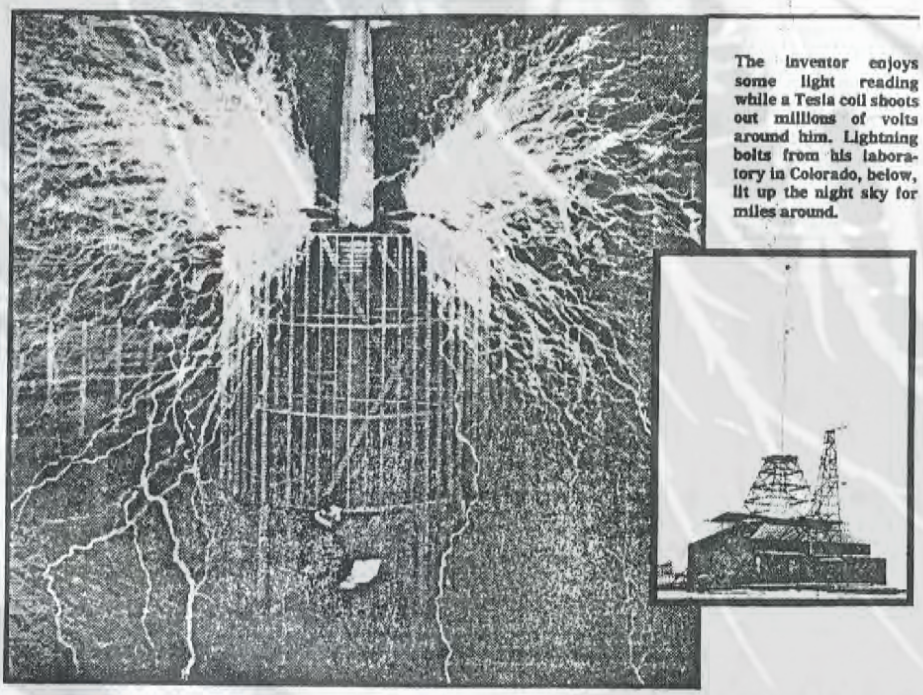
Tesla suggested in 1940 that the United States military could build a system of death rays that would melt enemy airplanes at a distance of 250 miles. The War Department looked into the idea and said politely, no thanks.

"With Tesla you're always going to get the fringe," said Robert K. Golka, a physicist who spoke at the symposium. "It's hard to tell what is real and what is not. Tesla will always attract guys with ideas about perpetual motion."

Indeed, Tesla himself was something of a character, according to Margaret Cheney, whose book, "Tesla, Man Out of Time," details some of the eccentricities. At the height of his fame, while eating dinner in the Palm Room of the Waldorf-Astoria Hotel, he would polish the already sparkling sliver and crystal using exactly 18 napkins. He had a phobia about germs and a love of numbers divisible by three.

The New York Times reported in a front-page article in 1915 that Tesla was to share that year's Nobel Prize in physics with Edison. But he never got the award. One biographer said that Tesla had refused to share it with his old rival. Another version has it that Tesla rejected the prize because it had been given in 1909 to Marconi.

After the death of his mother, Tesla became increasingly eccentric and withdrawn. He vigorously disagreed with theories put forward by great scientists of his day including James Clerk Maxwell and Albert Einstein. He never married. Nearly every day he would go to Bryant Park behind the New York Public Library and feed his friends, the pigeons. Late in life he announced that he had received signals from distant planets, a claim that was greeted with some skepticism.



The inventor enjoys some light reading while a Tesla coil shoots out millions of volts around him. Lightning bolts from his laboratory in Colorado, below, lit up the night sky for miles around.

Attracts Following of Fanatics

Waldemar B. Kaempffert, a science editor of The New York Times in the first half of the century, once described Tesla as "an intellectual boa constrictor" and a "medieval practitioner of black arts."

Tesla's closest living relative, Mr. Terbo, says that four basic types of people are attracted to Tesla — serious scientists, Yugoslavs proud of his achievements, pseudoscientists who pursue some of his wackier ideas and cultists who worship him as an extraterrestrial.

"There are religious fanatics in Pasadena who say he came down on a space ship from Venus," said Dr. Terbo, adding, "It's no small group."

Although Tesla is only belatedly being recognized for the wide-ranging brilliance of his achievements, one testimonial to his genius did come in 1917 from B. A. Behrend, an engineer who had an inkling of the mark Tesla would make on Western civilization.

"Were we to eliminate from our industrial world the results of his work," he told a banquet in Tesla's honor, "the wheels of industry would cease to turn, our electric cars and trains would stop, our towns would be dark, our mills would be dead and idle. His name marks an epoch in the advance of electrical science. From his work has sprung a revolution."

Tesla, a Bizarre Genius, Regains Aura of Greatness

By WILLIAM J. BROAD

THE world of science is belatedly recognizing the genius of one of its most important, eccentric and enigmatic inventors, Nikola Tesla.

A century after he arrived penniless on the docks of New York City, Tesla is receiving credit for brilliant achievements that outdid those of his contemporaries, Edison and Marconi. And more than 40 years after the recluse died in a Manhattan hotel room, in the company of the pigeons who were his favorite companions in the final years of his life, he is at last being elevated to the pantheon of the world's great inventors.

It was Nikola Tesla, not Marconi, who invented the first radio; it was Tesla, not Edison, who devised the system of electric power disribution now used throughout the world. Working in small laboratories in midtown Manhattan and Greenwich Village, Tesla invented the polyphase electric motor, the bladeless steam turbine and the radio-guided torpedo. Some scientists say it was Tesla who first conceived ideas for a "Star Wars" type of military shield in space.

To help analyze and publicize the accomplishments of the enigmatic genius, a group of scientists and engineers have formed the Tesla Centennial Committee and recently held a symposium, organized a museum exhibition and persuaded the Governor of Colorado to dedicate the month of August to Tesla.

"He helped spawn the industrial revolution," said Toby Grotz, chairman of the Tesla Centennial Committee and an engineer at Martin Marietta Aerospace in Denver. "It couldn't have happened without him. He came from a period when a single individual could still change the course of history."

The centennial events have largely taken place in Colorado, where the inventor had built a laboratory to create huge bolts of artificial lightning.

"We're trying to bring his name its rightful prominence," said William H erbo, who is Tesla's great-nephew and honorary chairman of the Tesla Memorial Society.

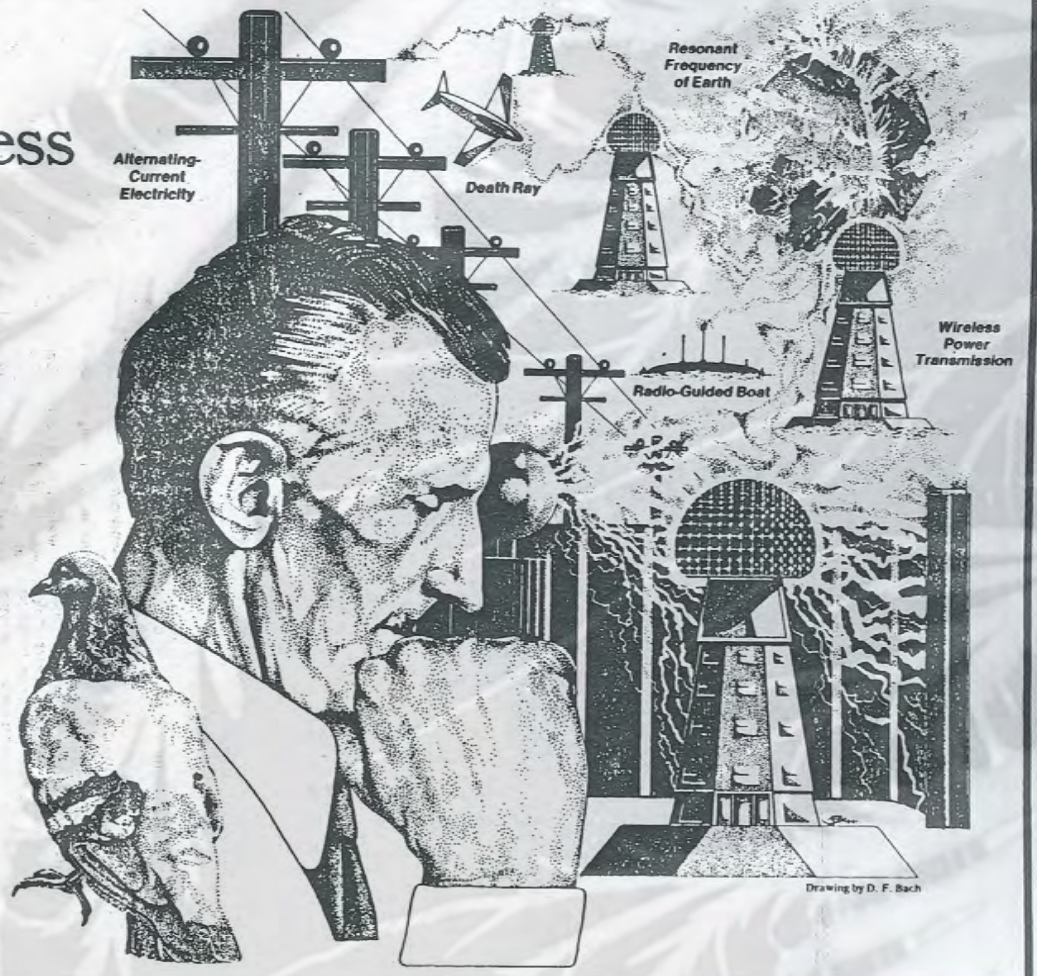
The proceedings of the symposium will be published by the New York-based Institute of Electrical and Electronics Engineers, the world's largest such society.

The committee says conventional histories all too often dismiss Tesla in a few paragraphs. Indeed, the usual story is quite short.

Tesla was born in 1856 in Croatia, then part of the Austro-Hungarian Empire, and soon showed a talent for invention and tinkering. In 1884, he took a ship to New York and im-

Continued on Page 21

Tesla, who shaped the country's course through radio, power transmission and other inventions, in the end sought the companionship of pigeons.



Awesome Power
IN A SETTING OF
Stunning Natural Beauty

Niagara! Perhaps no other river on Earth is as recognized for its awesome power and breathtaking beauty.

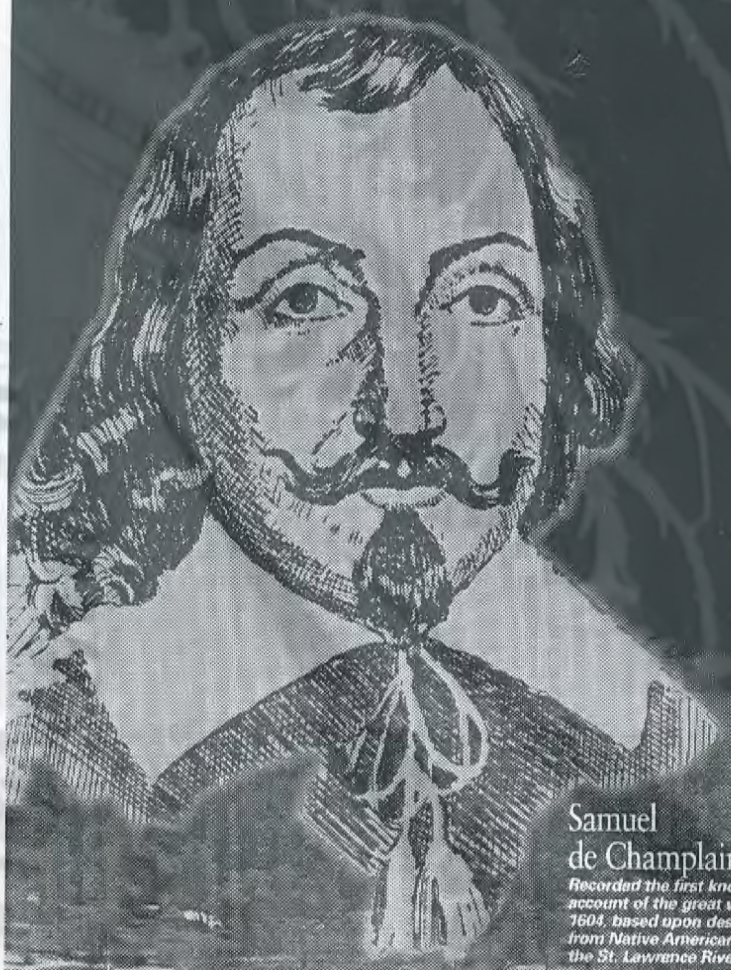
In 1604, Samuel de Champlain recorded the first western reference to Niagara Falls, repeating what Native Americans along the St. Lawrence told him about the river. He never actually saw the falls, however. In 1610, Etienne Brule, a member of Champlain's crew, was probably the first European to behold Niagara Falls.

As American civilization unfolded, Niagara Falls proved to occupy a strategic position on major land and water trade routes. Its attraction as a center of commerce and a site for harnessing water power grew by leaps and bounds.

The Industrial Revolution gathered force, and in 1841 the earliest calculation of the power of Niagara Falls was made. The flow was figured at 374,000 cubic feet per second.

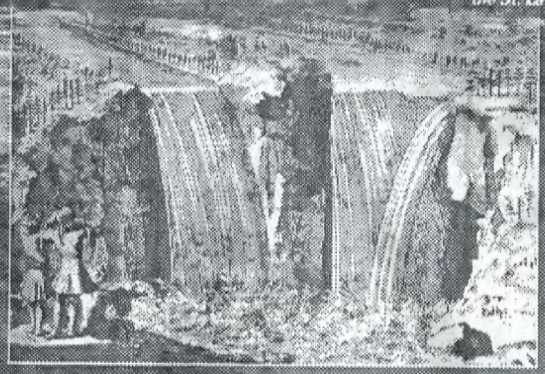
At a height of 160 feet, Niagara Falls was capable of imparting a total of 6,800,000 horsepower, of which two thirds – or more than 4,500,000 horsepower – could effectively be captured through water wheels.

The Falls' location, majestic splendor and staggering power were a magnet for tourists and developers the world over. Niagara Falls was and still is recognized as one of the "Wonders of the World."

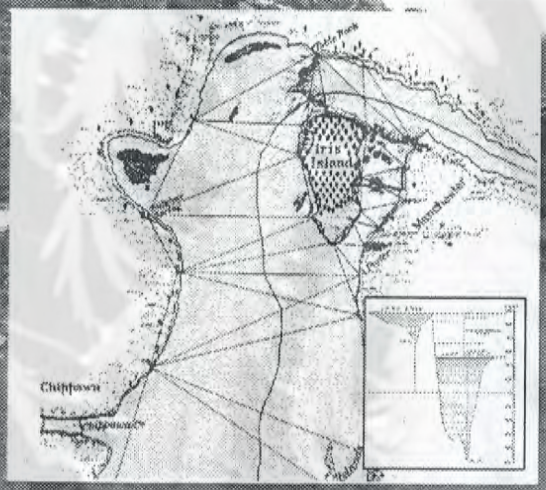


Samuel de Champlain

Recorded the first known account of the great waterfall in 1604, based upon descriptions from Native Americans along the St. Lawrence River.



Early French print of Niagara Falls dated 1697.



Map of the river and falls prepared in 1819 by commisssioners fixing the international boundary line.

Scale drawing of lake level, river and falls depth charted in 1925.



November 15, 1896

Niagara Mohawk

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076

Plaque Honoring Electrical Genius, Nikola Tesla, Dedicated at Manhattan's Hotel New Yorker

A commemorative plaque honoring the great inventor and electrical genius, Nikola Tesla, was unveiled at the Hotel New Yorker Ramada on Tuesday, July 10, 2001. The Tesla Memorial Society, the Institute of Electrical and Electronics Engineers (IEEE) and the Hotel New Yorker hosted the ceremony.

Known as the "Father of Alternating Current," Nikola Tesla, son of a Serbian Orthodox priest, was born on July 10, 1856 in the Austro-Hungarian Military Frontier Province town of Smiljan in what is now Croatia. After his higher education in Science and with practical electrical design experience, Edison interests in Paris recognized his talent and invited him to America in 1884 to work directly for Edison. They soon parted ways when Edison found no use for Tesla's seminal work on Alternating Current (AC) power.

Tesla's 1888 speech to the American Institute of Electrical Engineers (predecessor of the IEEE) on his innovations in AC power brought him to the attention of George Westinghouse. Westinghouse adopted Tesla technology, and eventually persuaded the U.S. power industry to replace the DC system, championed by Edison, with Tesla's polyphase AC system. With the 1896 completion of the Niagara Falls AC power generation and transmission system, AC became the world electrical standard.

Among Nikola Tesla's 700 patents was fundamental work in radio, fluorescent light, remote control, high voltage and high frequency currents. Every aspect of electrical and radio technology owes a debt to Tesla's fertile imagination. The International Unit of magnetic flux density is the "tesla."

Nikola Tesla, a Manhattan resident for nearly 60 years, lived at the Hotel New Yorker from 1934 to January 7, 1943. The plaque had been created in 1976 by the Yugoslav American Bicentennial Commission to commemorate his residence there. The plaque was moved in 1989 to an honored position in the United Engineering Building, the international headquarters of the IEEE, adjacent to the United Nations. When that building was recently razed the plaque was returned to its original intended location.

The dedication ceremony was held on the 34th Street exterior of the Hotel New Yorker, just west of 8th Avenue. Priests from New York metropolitan area Serbian Orthodox Churches performed the blessing to open the ceremony. The plaque was unveiled by former Congressperson, Helen Delich Bentley, and William H. Terbo, grandnephew of Tesla and Chairman of the Tesla Memorial Society. Remarks were offered by Bentley, Terbo and other honored guests.

WHT/tmslt(3)

NIKOLA TESLA PLAQUE

Dedication, Tuesday, July 10, 2001
Hotel New Yorker Ramada, Manhattan

Remarks By

William H. Terbo.
Executive Secretary, Tesla Memorial Society, Inc.

It has been a long trip, but this Plaque honoring the great electrical genius and humanist, Nikola Tesla, is now installed where it was first intended, his residence for the final ten years of his life – the Hotel New Yorker.

In these few moments, I would like to touch on two items of the story of Nikola Tesla and the Hotel New Yorker: my visit with him in him suite, and a brief history of the Plaque.

First, the visit. How is it that a young boy, myself, should have the opportunity to be ushered into the presence of such a famous and distinguished elderly man as Nikola Tesla. Simple. It was just a family matter. My grandmother was Tesla's sister, Angelina, and my father, Nikola Trbojevich (socially, Nicholas Terbo), was Tesla's nephew. (There was a special relationship between Tesla and my father in addition to the family connection. My father was the only other technically educated person in the extended family - the educational tradition was to become clerics in the Serbian Orthodox Church as Tesla's father, my grandfather and my father's eldest brother were. And my father was the only other family member to come to America. My father was 30 years junior to Tesla, also came to the U.S. at age 28, and died 30 years after Tesla.)

It was the 1930's tradition of our family to spend the summers at the New Jersey shore. The routine was for father, mother, my brother and I to motor from Detroit to the Cape May or Asbury Park. Father would stay for a week or two before returning to Detroit where he maintained offices as an inventor and consulting engineer. At the end of the summer, mother and I (my brother passed in 1937 at age 13) would return by train with a stopover of a week or so in either Washington or New York.

This particular year, probably 1938 or 1940 (kids are not so time specific) my mother and I were staying at the Taft Hotel with plans that day (I thought) to visit Radio City Music Hall. Imagine my surprise when, on the way to Radio City, my mother said "let's go see Uncle Nikola first." I was less than enthusiastic because Radio City seemed much more exciting.

Mother and I went to his Hotel New Yorker room Number 3327, a two-room Suite, in mid morning. He was waiting for us. He addressed my mother and then turned to me, kissing and hugging me in greeting. (As an All-American boy, I was much more comfortable with just shaking hands). Besides saying "Hello" or some such, I seemed to

be struck dumb. I may have, but I don't recall saying another word. Tesla was very tall and very old, while I was so small. Uncle Nikola and my mother talked for some time on family matters, perhaps on my brother's recent death, and we left to Radio City.

On reflection in recent years, I've wondered about Tesla's famous idiosyncrasy concerning a phobia of germs. His habit of wiping silverware and shaking hands most reluctantly were items of constant press coverage. Hugging, kissing and patting the head of a ten-year-old boy seemed out of character. Perhaps this idiosyncrasy was merely an affectation used to tease the press.

Now, the Plaque. The Yugoslav-American Bicentennial Committee conducted many cultural events in connection with America's 200 hundredth birthday celebration including technical symposia and folk art and dance festivals. The Plaque was their gift intended for installation here at the Hotel on January 7, 1977, exactly 34 years after his passing. (You may remember that almost every country in the world gave a "birthday" gift to America in 1976. The official gift of the Yugoslav Government was the statue of Nikola Tesla that was installed overlooking Niagara Falls.)

For reasons that are not necessary to detail here, that installation did not take place in 1977. After the Bicentennial Committee concluded its work, the Plaque languished in the offices of the Yugoslav Counsel General until 1989. Through the fortuitous intervention of Dr. Milan Bulajic, a doctor of international law, Director of the Yugoslav Nikola Tesla Fund, a former Yugoslav Counsel General at New York – and having some specific business with the Executive Director of the Institute of Electrical and Electronics Engineers (IEEE), Mr. Eric Herz – proposed placing the Plaque at the United Engineering Center adjacent to United Nations Headquarters. The Center was the International Headquarters of the IEEE as well as several other Technical organizations.

This suggestion met with success and immediate action. Nikola Tesla holds a special place in the regard of the IEEE: He is one of twelve "apostles" of electric technology honored by the IEEE, joining such luminaries as Michael Faraday, Samuel F. B. Morse, Lord Kelvin, Thomas Edison and Alexander Graham Bell.

The Plaque was installed on the wall of the United Engineering Center Lobby Honor Court directly opposite a similar plaque honoring Alfred Nobel, the philanthropist who provided the initial funding for the construction of the Center. There it remained until redevelopment (Donald Trump style) caused the razing of the Center last year. The IEEE became custodian of the Plaque until it could be returned to its original intended location.

On behalf of the family of Nikola Tesla and the Tesla Memorial Society, Inc. I want to thank all those who have been involved supporting this particular honor for one of the great men of technology. A man who may have had the greatest impact on transforming human society into what we may call the "modern" age. I want to thank the Bicentennial Committee, Dr. Milan Bulajic, Mr. Eric Herz and the IEEE current General Manager Daniel J. Senese, the Hotel New Yorker and General Manager Mr. Barry S. Mann for supporting this event.

Nikola Tesla's discoveries and inventions in electricity and radio are well known. His genius opened a path to a new world. He was a true pioneer. Many years ago an early American writer captured the thought this way:

> "Genius is the spirit of discovery. It gives wings to thought. It is always in advance of its time – a pioneer for the generations which it precedes."

Thank you.

William H. Terbo
Executive Secretary and Chairman of the Executive Board
Tesla Memorial Society, Inc.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

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WHT/tmsly(2)

THE TESLA MEMORIAL SOCIETY, INC.

THE HOTEL NEW YORKER

The Hotel New Yorker holds a special place in the biography of the famous electrical genius and inventor, Nikola Tesla, being his home from 1934 until his death on January 7th, 1943. As a single man and completely absorbed in his hundreds of inventions, he had little time to devote to the maintenance of a conventional household. He chose instead to live in a succession of luxury hotels. Because of his friendship and association with the Astor family, he lived for many years (1900-1919) in the old Waldorf-Astoria, now the site of the Empire State Building. In subsequent years he lived in the Hotel St. Regis, the Marguery, the Pennsylvania, the Governor Clinton and finally the New Yorker (1).

His 700 patents include the seminal inventions of the modern system of alternating current production, transmission and utilization; the basics of radio; and the high frequency Tesla Coil. These accomplishments made Nikola Tesla perhaps the youngest and greatest of that special group of independent inventors who were most productive around the turn of the Twentieth Century. Looking back after many decades on a man whose personality of culture, science and altruism makes him seem almost alien in the materialism of today. This has caused some people to attribute powers and drama to his life and his work that are not always well founded.

Among the stories associated with Nikola Tesla is that he died in poverty in 1943. While he did not retain the wealth and income that was his situation in previous years, he lived in a two-room suite in one of the most luxurious hotels in Manhattan, the Hotel New Yorker. To adequately position the New Yorker among the leading hotels of Manhattan during the years Tesla called it his home, it is appropriate to review some of the details of its construction and amenities (2).

The Hotel New Yorker opened for guests on January 30, 1930. With 2,500 guest rooms and 43 stories, it was the largest and tallest hotel in New York. At $22,500,000, it was the most costly hotel construction to that date. The hotel was self-sufficient in all aspects of electrical power, heating, cooling and ventilation for up to 3,500 hotel guests and up to 30,000 visitors daily. These facilities were located in four sub-basements as well as in several above ground areas. A staff of 2,000 provided a high level of guest, dining and banquet services.

Construction started in June of 1928, after the removal of obsolete structures on a plot of 197.5 by 175 feet on the west side of 8th Avenue between 34th and 35th Streets. The completed structure contained 10,400,000 cubic feet of enclosed space above ground and 2,000,000 cubic feet below ground. A tunnel connected the Hotel with nearby Pennsylvania Station. There was subterranean access to the New York subway system. A bank and several other commercial businesses were provided space and facilities in the public areas of the Hotel.

Air conditioning was provided to the main dining room, grill room, tearoom, banquet hall, main ballroom and eight private dining rooms by an odorless (carbon dioxide) refrigeration system of 166 tons capacity. Twelve all-automatic (but attended) main passenger elevators were provided, six local to the 19th floor and six express to the 20th to 39th floor. Six service elevators operated, three from the 3rd basement to the roof (44th floor) and three from the 3rd basement to the 39th floor. There were also two freight elevators (4th basement to 3rd floor); one large ballroom elevator (1st to 3rd floor); one large subway elevator (2nd basement to 2nd floor); and an elevator for the bank (1st basement to the 2nd floor). Four Hotel and one bank dumbwaiters were also provided.

Every guest room had a telephone. The Hotel maintained one of the largest private telephone exchanges to provide service, including a 24-position switchboard on the 39th floor. Every guest room had a (four program channel) radio. Tap ice water was available in every guest room in addition to regular hot and cold running water. Every guest floor had a room clerk station connected to the lobby by telephone, telautograph and pneumatic tube systems. (The Hotel maintained a 60-station pneumatic tube system for interdepartmental messaging.)

Electric power was provided by four steam-driven engines direct connected to three 600-kw and one 400-kw DC generators and one 535-hp diesel engine direct connected to a 375-kw DC generator. The 2,575-kw capacity was sufficient not only to provide 115 volt light and 230 volt power for all Hotel uses, including 200 motors used for other Hotel services, but to provide service to all adjoining buildings. (Normal usage was for two units running and two units plus the diesel unit in reserve.) The Hotel did not convert to Alternating Current until about 1965.

As the comfort and convenience of guests was paramount in the running of a luxury hotel, all service systems and facilities tended to be designed with large safety margins for the original 1930 Hotel New Yorker. This over-design is certainly a significant factor in the continuing popularity of the current Hotel New Yorker, 71 years young.

William H. Terbo
Executive Secretary

Tesla Memorial Society, Inc.
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076

(1) Tesla residence information by Leland I. Anderson, copyright 1990.
(2) Hotel New Yorker construction and service systems information by POWER magazine, November 26, 1929 issue, copyright 1929.
Special thanks to Mr. Barry S. Mann, General Manager, and Mr. Joseph Kinney, Chief Engineer, New Yorker Hotel Management Company, Inc.

November, 2001 WHT/tmsmt(2)

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TESLA MEMORIAL SOCIETY, INC.
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TESLA: MASTER OF LIGHTNING ***40,000 in print***
By Margaret Cheney & Robert Uth

Tesla: Master of Lightning, the 1999 companion book of the 2000/2001 PBS Television Special of the same title, is the most comprehensive illustrated biography of the great electrical genius, Nikola Tesla, yet produced. The authors are well-known biographer and Society Executive Board member Margaret Cheney and documentary producer, director and writer Robert Uth. In its third printing, the attractively priced 184-page, 9x11¼ inch, hard cover book contains over 225 photos, drawings and illustrations, with authoritatively researched and dated captions. The text provides a thorough and skillful overview of Tesla's life with many pertinent sidebars with details and anecdotes. *Tesla: Master of Lightning* contains a fully detailed list of References, Bibliography and Index and is available at bookstores (ISBN 1-5866-3187-X or 0-7607-1005-8).

TESLA: MAN OUT OF TIME ***200,000 in print***
By Margaret Cheney

Margaret Cheney's 1981 biography *Tesla: Man Out of Time* accurately anticipated the resurgence of interest in Nikola Tesla, the man and his place in history. The many previous Tesla biographies dealt more with the drama, mystery, romance, controversy or frustration of his remarkable life rather than the importance and societal impact of his discoveries and inventions. In *Tesla: Man Out of Time* Ms. Cheney combined all of those elements into an excellent "read" that nevertheless accurately researched the technical detail necessary to position Tesla in the context of modern society.

The staying power of *Tesla: Man Out of Time* has been impressive. The original 1981 hard cover edition was followed by a soft cover edition in 1983. A second hard cover edition was published in 1993. Two additional soft cover editions were published in 1998 and 2001. The cumulative volume effect of multiple printings has pushed *Tesla: Man Out of Time* into the industry accepted standard of a "best seller." Hard cover editions are hard to find but various soft cover editions are available at bookstores.

Tesla: Man Out of Time has been translated into several foreign languages including German, French and Japanese. A Korean language version is currently in process. This is another indicator of the renewed worldwide interest in Nikola Tesla

The Tesla Memorial Society, Inc., founded in 1979 and incorporated in 1980, is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla, the "Father of Alternating Current." The Society is a nonprofit, nonpolitical, all volunteer membership organization operating under Section 501 (c) (3) of the Internal Revenue Code.

NY TIMES Tues 7/6/82 Pg C3 THE NEW YORK TIMES,
"SCIENCE TIMES" SECTION

Science Library

Tesla: Man Out of Time

By Margaret Cheney. Prentice-Hall. 320 pages, illustrated. $16.95.

It is difficult to think of a scientist-inventor of the past century more fascinating and enigmatic than Nikola Tesla. He was not universally admired. Waldemar Kaempffert, a former science editor of this newspaper, described him as "an intellectual boa constrictor," a "medieval practitioner of black arts . . . as vague as an oriental mystic."

Yet Tesla is widely credited with inventing the technology of alternating current systems that now dominate electrical technology. He won financial backing from such figures as J. P. Morgan.

So far, no professional historian of science and technology has sought to document Tesla's turbulent life, separating the facts from the grandiose claims made on his behalf, particularly by some Tesla admirers who share his Croatian origins. He has been credited with outshining Edison as an inventor and being the true discoverer of vacuum tubes and of wireless telegraphy — accomplishments usually credited to others.

Margaret Cheney, a California writer and journalist, became interested in Tesla's story in the 1950's and joined in formation of the Tesla Society, since disbanded, to help celebrate the centennial of his birth in 1856. In preparing this book she has delved into a rich collection of source material and, in spite of her obvious admiration for her subject, she spells out the extraordinary idiosyncracies and boastful declarations that infuriated contemporary scientists.

With a pocket-size vibrator, he told reporters, he could generate resonant tremors that would collapse such large structures as the Empire State Building and the Brooklyn Bridge. He said he could split the earth "as a boy would split an apple" and gave its resonant frequency as one hour and 49 minutes.

Whatever the basis for this rather precise estimate, he was not very far off the true resonance period, as was demonstrated by the great Chilean earthquake of 1960. The book is informative and highly entertaining, but it still remains for a science historian to place Tesla in his rightful place among the geniuses of the past century.

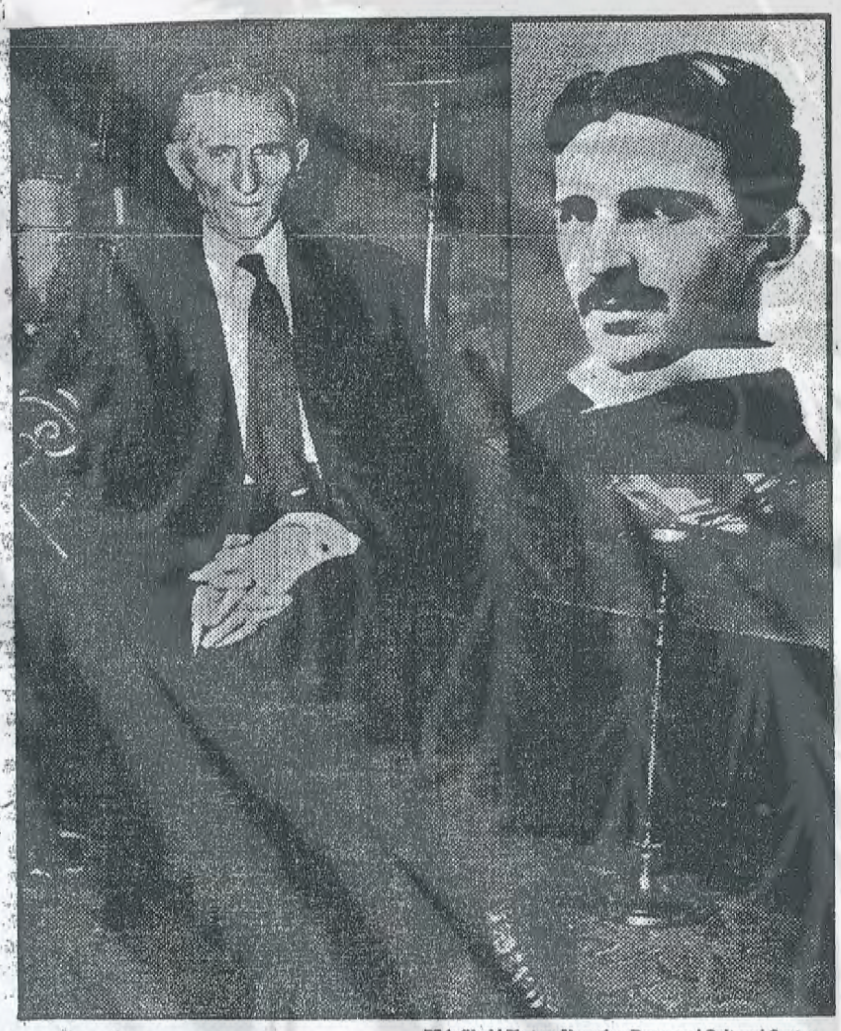
WALTER SULLIVAN

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WILLIAM H. TERBO
Executive Secretary

Visit our website: teslamemorialsociety.org



Wide World Photos; Yugoslav Press and Cultural Center

The inventor Nikola Tesla on his 78th birthday in 1934 and as a young man.

TESLA: MASTER OF LIGHTNING

PREVIEW SHOWING AND RECEPTION – TUESDAY, DECEMBER 5, 2000
NATIONAL ACADEMY OF SCIENCES, WASHINGTON, D.C.

The National Academy of Sciences in Washington hosted a reception and preview showing of the new PBS Special *Tesla: Master of Lightning*, produced and directed by Robert Uth of New Voyage Communications. The 90-minute video production is a dramatic multimedia documentary of the prolific Serbian-American inventor and visionary, Nikola Tesla (1856-1943). His many patents form the basis of the modern Alternating Current power generating, transmission and utilization system as well as the fundamentals of radio and television transmission. (PBS network broadcast feed of the production occurred at 10:00 pm, Tuesday, December 12, with the initial public viewing throughout the PBS network at that time or at times convenient to local markets.)

The Academy program began at 6:00 pm with an hors d'oeuvre and cocktail reception in the rotunda area of the Academy. Over 200 guests were treated to demonstrations of working models of an early Tesla Coil and other equipment used in the *Master of Lightning* production. At 7:00 pm, the guests adjourned to the Academy auditorium for the balance of the program.

Dr. William Wulf, President of the National Academy of Engineering, as host for the Academy, spoke briefly in welcome and to recall for the audience of the importance of Tesla's scientific and engineering contributions to modern society.

Robert Uth spoke next to describe the many years of research, and the development of the production from original concept to realization. He recognized Phylis Geller, Executive Producer and co-writer, and other members of the New Voyage team with whom the documentary was made.

Molly Hughes of Tessco Technologies, Inc., which hosted the reception, spoke of the elements of Tesla's radio technology so fundamental to products developed by Tessco.

William Terbo, Executive Secretary of the Tesla Memorial Society and grandnephew of Nikola Tesla, expressed his appreciation for the production for the Society and the family. He also acknowledged the impact this PBS Special will have on increasing public awareness as to Tesla's legacy in creating the modern industrial society.

Dr, Bernard Finn, Curator of Electrical Collections, Smithsonian Institution's National Museum of American History, spoke of Nikola Tesla's prominence in the golden age of independent inventors.

The preview of *Tesla: Master of Lightning* followed at 7:30. *Master of Lightning* is the first network documentary to be made about Nikola Tesla. It is scientifically and historically accurate, as well as entertaining. Much of the story is told in Tesla's own words (performed by prominent actor, Stacy Keach) from his autobiographical and

scientific writings. Science Advisor is Leland Anderson, prominent writer on Tesla technology and leading Tesla historian. The PBS Special is supported by a companion book and website,

Extensive additional information on Tesla's life and inventions is available on the website: www.pbs.org/tesla

The companion book ***Tesla: Master of Lightning*** by Margaret Cheney and Robert Uth, is published by Barnes & Noble Books.

Historical Note:

The National Academy of Sciences is one of the most prestigious venues in Washington. On November 20th 1981, the Society hosted a reception and program at the Academy celebrating the 125th Anniversary of Nikola Tesla's birth. Event arrangements and invitations were managed by Society Washington Liaison, Congressman, the late John Blatnik. Over 250 attended the program including many members of Congress, governmental and diplomatic notables and the press. Individuals and organizations participating as program speakers included the President of the IEEE, the Power Engineering Society, the Ambassador of Yugoslavia, Society Executive Secretary, the late Nicholas Kosanovich, and Honorary Chairman, William Terbo, grandnephew of Tesla. A showing of the movie The ***Secret of Nikola Tesla,*** starring Orson Welles, concluded the event.

For more information: www.teslamemorialsociety.com or .org
and www.newvoyagepublishing.com

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WHT/tmskt

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076, USA

William H. Terbo
Executive Secretary

Maria Godfors
Treasurer

TO: RADIO TELEVISION OF SERBIA

The Tesla Memorial Society wishes to congratulate Radio Television of Serbia and all the people of Yugoslavia on the important events of this October: the 75th Anniversary of Radio Belgrade; the 50th Anniversary of Radio Novi Sad, memorialized by the installation of a bust of Nikola Tesla at Radio Novi Sad Headquarters; and, the Yugoslav Day of the Inventors, dedicated to the greatest of inventors, Nikola Tesla.

Until Nikola Tesla, theories in radio were the province of physicists such as Faraday, Maxwell and Hertz. It was Tesla, both a physicist AND an engineer, who turned those theories into practice. He was the first to announce the possibility of transmitting intelligent messages without wires, who devised the antenna/ground system, who invented the use of tuned circuits at both transmitter and receiver, who conceived of resonant frequency tuning and who created the radio frequency generator. The result of this burst of genius is radio as we know it today.

The Tesla Memorial Society is the oldest U.S. based organization in continuous operation honoring the memory and ideals of the great electrical scientist, Nikola Tesla. It is our pleasure to cooperate with people of all walks of life who join with us in recognizing the unparalleled contributions of this singular man.

On behalf of the Tesla Memorial Society, its Executive Board and Membership, we send our most sincere regards to all who have participated in these events and to Serbians, wherever they may live, who will forever recognize the gifts bestowed on the entire world by one of their own, Nikola Tesla.

William H. Terbo, Chairman of the Executive Board

October, 1999

An Unknown Scientist WITH A Revolutionary Theory



Nikola Tesla
and the famous "Tower of Light" from the 1893 Chicago World's Fair.

Born in Croatia to Serbian parents in 1856 – just nine years after Thomas Edison – Nikola Tesla would become known as an uncommon genius with a mind for invention. Tesla had a lifelong dream of harnessing the power of Niagara Falls to benefit humanity. He envisioned its cascading waters powering a giant wheel – and a nationwide electric system.

At age 28, Tesla came to the United States. Four years later he announced his invention of the "polyphase alternating current system." Alternating current was viewed as a more efficient way to transmit electricity over great distances. Until Tesla's system, however, the technology did not exist.

Tesla's discovery - that a rotating magnetic field is produced by two or more currents alternating out of step - made transmission possible over hundreds of miles. This opened a new age of limitless electric light and power.

Tesla's 1888 announcement before the American Institute of Electrical Engineers captured the interest of George Westinghouse, the Pittsburgh railroad entrepreneur who was systematically buying up electrical patents and developing a full-scale frontal attack on Edison's direct current system.

In 1893, Tesla and Westinghouse contracted to install the power and lighting equipment for the Chicago World's Fair, also known as the Columbian Exposition. This successful demonstration of alternating current set the stage for its use at Niagara Falls.

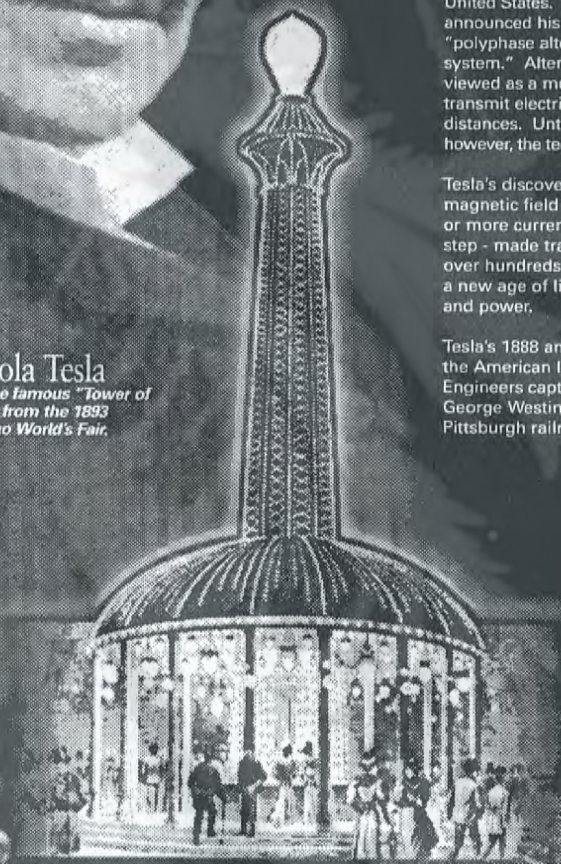
While Thomas Edison is remembered today as the man who laid the foundation for the technological and social revolution of the modern electric world, it was the unsung genius of Nikola Tesla that made it possible for that revolution to spread across this country and around the world over long-distance electric lines.



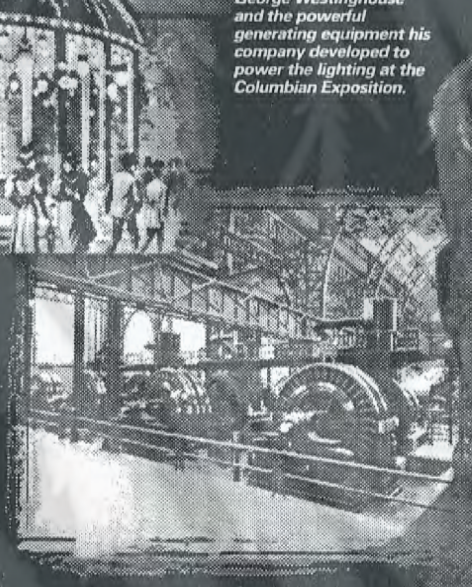
November 15, 1896

Thomas Edison, and his invention of the electric lamp, drove pioneers like Nikola Tesla to develop reliable and economical means of transmitting power over long distances.

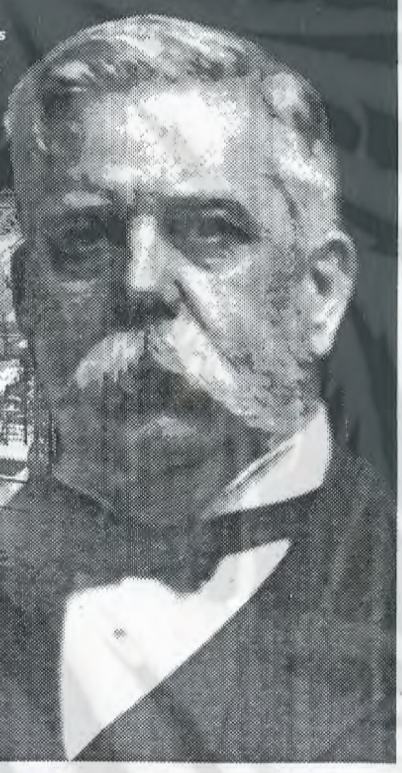




George Westinghouse and the powerful generating equipment his company developed to power the lighting at the Columbian Exposition.







Niagara Mohawk

Great Risk– Great Reward

In 1883, Thomas Evershed, an engineer for the Erie Canal, suggested building a gigantic tunnel to tame the power of Niagara Falls. The mile-long tunnel would run under the village of Niagara Falls. It was to be the greatest engineering work of its kind.

In 1889, a group of New York bankers agreed to put up the money for the tunnel on the condition that Edward Dean Adams, a lawyer, engineer and banker, personally look after their interests.

Experts studying the Niagara project considered the transmission of power by wire rope, compressed air, water piped under pressure, and even by electricity.

By the late summer of 1890, Adams' International Commission, composed of the greatest scientific and engineering minds of the world, decided that power would be generated at a central station in the form of electricity, using water from the Niagara River above the Falls. The water would be routed through the tunnel and discharged below the Falls.

The tunnel was started in October 1890. Twenty-five hundred men removed 600,000 tons of rock and dirt.

Orders went out for the station's giant turbines – larger than the world had ever seen.

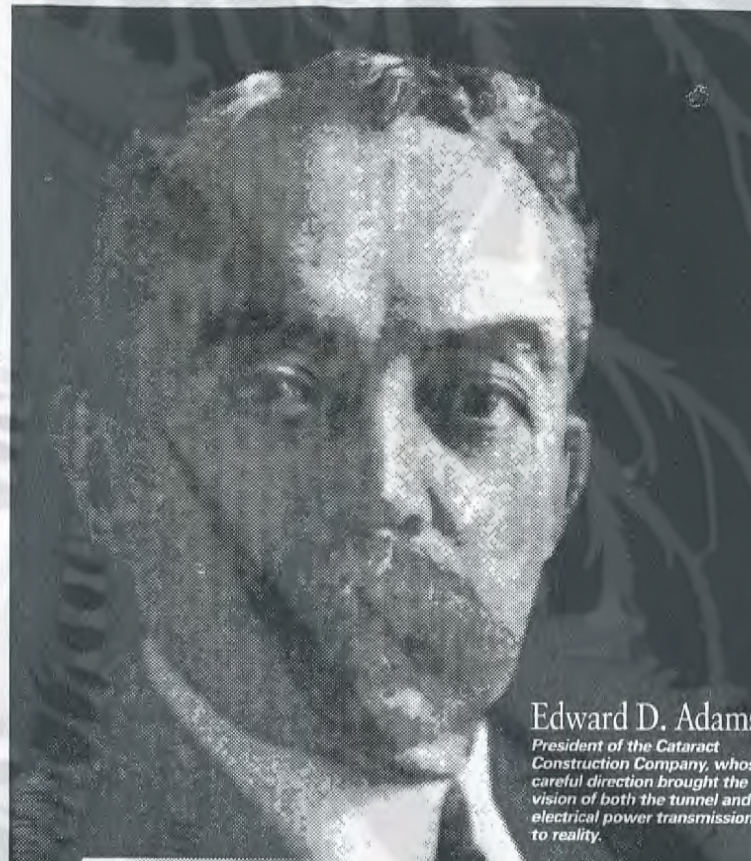
By April 1895, the first hydroelectric unit at the Adams Station was tested successfully. In 1896, Edison's General Electric Company completed construction of a 10,000 volt transmission line stretching 26 miles from Niagara Falls to Buffalo.

At midnight on November 15, 1896, electricity produced from the waters of Niagara Falls was transmitted to Buffalo, the Queen City of the Great Lakes.

The genius, sweat and daring of Tesla, Westinghouse, Adams and Edison mean that today reliable, safe, electric energy is available anywhere, anytime.



November 15, 1896

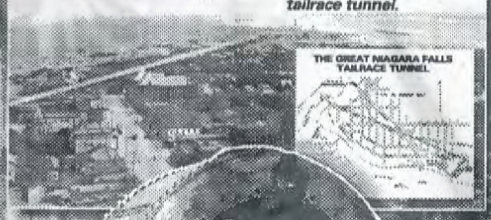


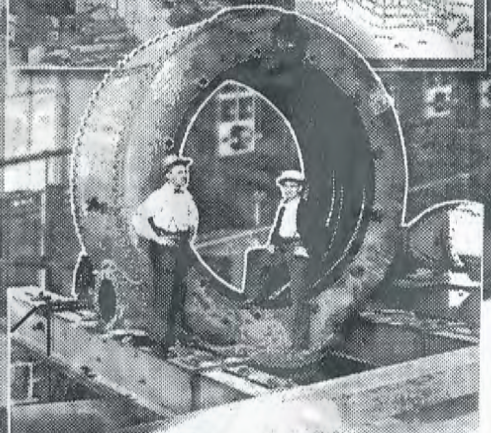
Edward D. Adams

President of the Cataract Construction Company, whose careful direction brought the vision of both the tunnel and electrical power transmission to reality.



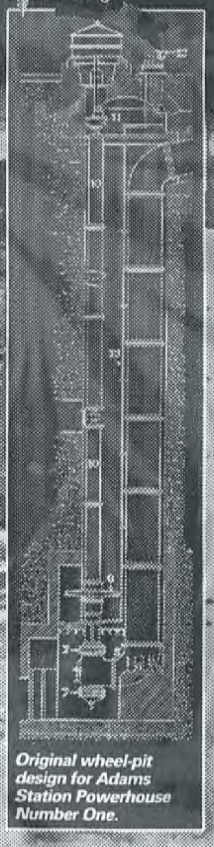
Intersection of a wheel-pit discharge from the Adams Station into the 24-foot-high main tailrace tunnel.





The construction of Adams Station called for enormous turbines – the largest the world had ever seen.

Interior of the Adams hydroelectric station as it began full operation in 1895.



Original wheel-pit design for Adams Station Powerhouse Number One.

Niagara Mohawk

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076
November 11, 2003

To all interested parties:

Ref: **Tesla Energy Science Conference**

The Integrity Research Institute held the Conference at the Sheraton College Park Hotel, Beltsville, Maryland, on Saturday and Sunday, November 8th and 9th 2003. More than a dozen contributors presented in a program of Tesla oriented topics to an audience of about 150. Congratulations to the Institute and their President, Dr. Thomas Valone, for a very successful and informative program. I thank the Institute and Tom Valone for their care, attention and hospitality for both Boyana and me.

My contribution was *A Family Perspective on the Personality of Nikola Tesla*. My presentation also included a review of the history and current status of the Tesla Wardenclyffe Tower, featured by the Conference in honor of its 100th anniversary, and a recap of recent books and video documentaries in which Tesla is featured. Copies of my remarks are available upon request.

My colleague and friend Dr. James Corum who, as an introduction to his presentation on Tesla RF technology, spoke with great energy and appreciation of the true debt the world owes to the many and varied contributions of Nikola Tesla. He showed how Tesla combined all the elements of the great scientist he was, rather than the mysterious or psychic loner as he is often portrayed. I thank Jim for those words.

As usual, the time available did not permit me to outline the most recent video documentaries. Of particular note is *The Battle of the Currents* a 50-minute program produced by a respected German documentary firm in German, French and English versions. Now in postproduction, it is scheduled for U.S. presentation on the Discovery Channel in the autumn of 2004.

William H. Terbo
Executive Secretary
(732) 396-8852



WHT/tmsrf

The Tesla Memorial Society, Inc. *is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla. The Society supports various cultural activities, participates in appropriate academic conferences and provides a source for an accurate representation of Nikola Tesla for the media. The Society is a non-political, non-profit, all volunteer membership organization founded in 1979, incorporated in 1980, operating under Section 501 (c) (3) of the U.S. Internal Revenue Code.*

Visit our website: *teslamemorialsociety.org*

TESLA ENERGY SCIENCE CONFERENCE

Integrity Research Institute
Beltsville, Maryland
November 8th and 9th, 2003

Comments By

William H. Terbo
Executive Secretary
Tesla Memorial Society, Inc.

I have been dealing with the personality, accomplishments and ideals of Nikola Tesla for almost my entire life. The form of that attention has changed over the past sixty plus years from the family aspect of a simple and respectful recognition of a man from another age who just happened to be my father's uncle to being closely associated with the popular revival of interest in a giant often regarded as the greatest inventive mind of the modern technological era.

Nikola Tesla has been the subject of every facet of modern media, both directly and in the context of other aspects of history, technology and his impact on today's society. Over the years hundreds of articles have focused on him, dozens of books have recounted his life and accomplishments, a score of documentaries have featured his place in modern history and more than one feature film have been devoted to this remarkable man. Most of these works have sought to capture something of the essence of this dramatic but enigmatic man. But even the most diligently prepared works focus on the American years of invention and conflict with but a cursory sketch of Tesla's early years and but a distant appreciation of the philosophy and sensibilities that drove the man. Often the research done relied on earlier, less reliable, work with the effect of compounding errors of fact and detail.

Today, I would like to touch on three areas of Tesliana: First, a little background on current areas of Tesla recognition and some personal thoughts on the private character of Nikola from a family point of view; then, a brief history and current status of the featured topic of this conference, the Wardenclyffe Tower; and in conclusion, a recap of books about Tesla (the cool medium) and network video documentaries (the hot medium).

TESLA RECOGNITION

Tesla's name is much more familiar to Europeans than to Americans. His name appears (as a brand) on widely distributed household light bulbs and appliances in Eastern and Southern Europe. Many large-scale electrical installations bear his name in Europe and elsewhere. (I understand that the new scientific Particle Accelerator under construction in Germany is to bear Tesla's name.) In Europe, outside of the former Yugoslavia, this significant level of recognition does not regularly extend to busts and plaques.

However, many American locations linked to Tesla are recognized with plaques, street names and so forth. The most impressive is a more that twice life sized statue of Tesla overlooking Niagara Falls, the 1973 Bicentennial gift to the United States from the government of Yugoslavia. Tesla is depicted seated, on a raised pedestal, with a set of plans spread across his lap. This "seat" in his lap provides an inviting photo opportunity for parents of children visiting the Falls. (Such a video clip was a part of this year's *I@NewYork* tourism campaign).

To date, bronze busts of Tesla (with black granite bases and bronze plaques) have been placed in honored locations in ten of America's leading universities, the result of a nonprofit citizen's campaign led by an educator, John W. Wagner. (Funding for the busts comes from personal funds, gifts, grants and the sale of thousands of high quality "Tesla" T-shirts. For more information e-mail: *jwwagner@concentric.net*).

HISTORY

Nikola Tesla was a superstar of a hundred years ago and the popular darling of the print media much in the manner of today's movie stars and sports heroes. (Remember, Engineering was once the stuff of romance.) The stardom thrust on Tesla started with the introduction of his alternating current system in the early 1890's and captured the imagination of the entire world with the harnessing of Niagara Falls in 1896. The connection between efficient and transportable electric energy quickly replacing previous inefficient methods with an accompanying decrease in exhausting manual labor was not lost on the general public. They credited the improvement in productivity and living standards to Tesla. Soon the public clamored to hear the details of each new discovery of this scientific icon.

That fame continued in a somewhat more modest measure through the 1930's while he lived. But after his death in 1943, this recognition quietly faded as the nation and the world concluded the World War and directed its attention to reconstruction and an explosion of new technology. It took another 25 years for people to reflect on just who was responsible for the new standard of ease and comfort enjoyed by modern societies. The name of Nikola Tesla, now almost completely unknown to the new generations, kept appearing when talk turned to the creative source of the technology that brought electric power, radio and a host of other everyday devices to the masses.

My father, Nikola Trbojevich (Nicholas J. Terbo) was the son of Tesla's eldest sister, Angelina. (At my Anglo-American mother's preference, we used the social name of Terbo and I was born with that name – father's professional name of Trbojevich was well established before their marriage in 1923.) Until my father's generation the Tesla and Trbojevic (the Serbian spelling) families were almost exclusively clericals in the Serbian Orthodox religion living nearby in the same Austro-Hungarian Military Frontier province county of Lika (now a part of Croatia) directly facing, at that time, the Ottoman Empire's most westward reach.

Two important elements established a special link between Tesla and father (30 years Tesla's junior): they were the only members of the extended families who were technically educated and the only members who immigrated to America. Father's professional and financial standing was secured by his invention of the Hypoid gear, used on the vast majority of the world's automobiles since 1930. The Hypoid gear introduced advanced mathematics to the art of gear design much as Tesla united electrical theory and electrical engineering. Tesla reveled in referring to father as "my nephew, the mathematician." Their family and intellectual connections made for frequent contact between New York and Detroit by visit, phone, telegram and mail.

My relation to Tesla's fame was quite subdued during the time of my education and early professional life. If it hadn't been for the Tesla Coil, which a few of the most enterprising high school age youngsters chose to build after winding their first electric motor, I don't think Tesla's name would have ever surfaced in that environment. With me, it was which engineering school I would attend – not what career I would pursue. My father's professional success combined with Tesla's reputation created a momentum too hard to resist. In those days I never offered up my relationship to Tesla without some specific reason. In all my courses in Electrical Engineering Tesla's name was introduced but once, and that in connection with the Coil. (However, when I took a course in gear design, my father's specialty, the Professor made me rise and be recognized - such was my father's more current reputation.)

After college I went to Los Angeles and became a part of the missile and space industry. With the exception of a very few scientists and people of Slavic background, particularly Serbs, Tesla's name was completely forgotten there. A woman of German origin I knew in Los Angeles danced with a Yugoslav folk dance club. I suggested that she might want to mention to her friends in the group that she knew one of the closest living relative of Nikola Tesla. The next day she told me they said "impossible that a close Tesla relative would be in Los Angeles" and they didn't believe me! I had to provide family detail to convince them. It was my first realization of the almost reverential regard Serbs and other Slavs hold for Tesla.

During my Los Angeles years my Secret clearance restricted my international travel particularly to Eastern Europe, including Yugoslavia. In 1973 I made a career change to satellite telecommunications and relocated first to Washington, DC and then to the New York City metropolitan area. It was a pivotal time in the renewal of interest in Tesla, both for his scientific accomplishments and for the intriguing texture of his personality. To my amazement, the level of activity concerning Tesla in the East was exceptional and well publicized. In 1975 Nikola Tesla was inducted into the National Inventors Hall Of Fame with Orville and Wilbur Wright, Samuel F. B. Morse and Guglielmo Marconi. The Hall is sponsored and publicized by the United States Department of Commerce. The Bicentennial Year of 1976 brought forth a torrent of honors. By 1975 my relationship to Tesla had been more widely known and I have been pleased to accept the Inventors Hall Of Fame diploma, the 1983 issuance of a U.S. Postal Service commemorative stamp and many other such honors in the family name.

In 1979 I was able to make my first trip to Yugoslavia. The reception accorded to me was only a small measure or the almost religious esteem in which Tesla is held in the land of his birth. No appointment was withheld, no courtesy was denied. Travel was arranged throughout the entire country including Tesla's and my father's birth county of Lika. I was finally able to visit the Nikola Tesla Museum in Belgrade where the bulk of his estate is preserved. The Museum possesses over 1,200 exhibits and 160,000 pages of documents plus hundreds of other items of memorabilia, including more correspondence with my father than I retain at home.

PERSONAL THOUGHTS

Let me talk for just a minute about the personality and character of Nikola Tesla. Much has been written about his public persona, usually dealing with the creation and implementation of his inventions and discoveries. Such writing tends to show a man of overwhelming intellect, dedication and perseverance. It creates a picture of a somber and sober person with a single-mindedness that seems to preclude a more human side. Much has also been speculated on the private side of Tesla. This speculation has been much influenced by his fastidious dress, his formal manners and his precise writhing style. Aside from the more outrageous speculations, the conclusion drawn that this was an introverted and driven workaholic without a fully developed personal side. However, put in the context of the times, dress, manners and precision in writing were really hallmarks of the decades on either side of the turn of the century. We have very few instances of verifiable anecdotes from his closest friends because such gossip rarely found its way into print. (What a change from today's celebrity bashing.) But, in context or out of context, these characterizations of Tesla's private personality have been perpetuated.

I've thought of this and believe that I may very well have a unique insight into Tesla's private personality through a comparison with my father. The parallels in their lives far exceed the common gene pool formed by their blood relationship. Except for being 30 years apart in age, the list of parallels is truly staggering:

- Both born in the Austro-Hungarian Military Frontier Province county of Lika where periodic military incursions by the Ottomans created a special sense of danger and responsibility among the border Serbs.
- Both sons of Serbian Orthodox priests and were raised in a very severe and demanding faith.
- Both received high level technical educations far from home, necessary in those days as such education was not available in the provinces. Tesla was educated in Graz and Prague, father in Budapest.
- Both worked in Budapest for similar lengths of time and immigrated to the United States at 28 years of age.
- Both exhibited qualities of dedication, patience, modesty and a philosophical turn of mind and, as inventors, made their most important inventions in their middle thirties.
- Both suffered from a certain naivete, particularly in business, and acquired, but let slip from their hands, a considerable fortune, and were ultimately frustrated.

- Both were strong and vigorous and died at 86 (Tesla) and 87 (father).

Considering my father's personality and some of the anecdotes father told me about Tesla, I believe that many of the affectations and idiosyncrasies so linked to Tesla (aversion to pearls, fear of germs, reluctance to shake hands, super sensitivity to sound and so forth) were well under control. Some, in his later life when the need to keep the press interested was more important, were consciously exhibited. I think it amused him. His wiping the silverware, measuring the volume of his meals and favoring multiples of three is simply manifestations of mildly compulsive-neurotic tendencies. Better to do something rather than sitting idly waiting for dinner to be served.

(When I met him as a seven, eight or nine year old boy, Tesla, 80 years old, hugged me, kissed me in the Serbian manner and mussed my hair. This is hardly something for a person to do if in fear of germs. Eight-year old boys must be crawling with germs, regardless or how recently washed!)

While both Tesla and father had serious religious upbringing, I believe both were governed by ethics rather than doctrine. I believe both had their feet firmly on the ground when philosophizing and the most religion-inspired thought they had was a duty to serve their fellow man. My father often said he would prefer the Nobel Prize to a million dollars. That was long before the Nobel Prize WAS a million dollars. (My mother said she would prefer the million.)

And that brings me to an unexpected point. Father had a good sense of humor and could hardly finish telling a funny story without bursting into roars of laughter. Some of the stories were from childhood in the old country – stories similar to the ones Tesla probably knew and that tickled him. A friendship with Sam Clemens must have a strong element of humor in it. When you next think of Nikola Tesla, that discoverer of great concepts, think of him with a smile on his face and a laugh on his lips.

THE TESLA MEMORIAL SOCIETY, INC.

To bring a focus to the increasing number of Tesla-oriented activities, the Tesla Memorial Society was founded in 1979 and incorporated in 1980 as a non-profit, non-political, all volunteer membership organization operating under Section 501 (c) (3) of the U.S. Internal Revenue Code. The Society Charter is to "honor and perpetuate the memory and ideals" of Nikola Tesla through support of and participation in various cultural activities and as a source for speakers and media contact. The Society is the oldest U.S. based international organization honoring Nikola Tesla in continuous operation. In 1980 I became a part of the Society first as Honorary Chairman, later as Chairman of the Executive Board and more recently as Executive Secretary. One of my principal tasks with the Society is to write and speak about Tesla the man in a correct way that neither deifies him nor holds him to unqualified gossip.

William H. Terbo 9 November 2003 © 2003 WHT/tmsrc2

TESLA ENERGY SCIENCE CONFERENCE

WARDENCLYFFE TOWER

HISTORY

By 1900, at the age of 44, Nikola Tesla had already accomplished the equivalent of several lifetimes of scientific work and invention. He had conquered the entire system of alternating current, demonstrated radio and robotics and had recently concluded his seminal experiments in high-frequency electricity in Colorado Springs. Those experiments confirmed to Tesla that he could deliver power without wires on a small scale. He felt he was on the threshold of a whole new technology and he needed to transfer those Colorado results to a project of grander scale. The project he chose was the Wardenclyffe tower. It became his financial undoing.

To this point, Tesla had been rewarded with a fortune from the sale of patents and consulting work. But this was a fortune in personal terms – not a fortune in industrial or business terms. His reputation was so well founded that he attracted the attention and financial backing of both private wealth and corporate capital. (Even the cost of his Colorado experimentation was beyond his personal resources and was mostly privately funded.) The business potential that Tesla foresaw from his new project was such that the lack of personal money should not be a problem. In June of 1900, Tesla set out to acquire the necessary funding. By November he had a $150,000 commitment from J.P. Morgan with an agreement to build a system within a year to transmit messages across the Atlantic.

Tesla's vision of the future of his system was astonishing in the context of the time. He foresaw all aspects of wireless power and radio transmission: civil and commercial radio, radiotelephone, mobile telephones, air and sea remote control devices, even television! He later called his project the *World System* of intelligence transmission. The full details of his vision were too ambitious to be divulged all at once for fear that they would be interpreted as deranged. This would prove to be an impediment later as Tesla's vision was orders of magnitude more enterprising than simple Trans Atlantic message transmission. This was a period in which Tesla more often chose secrecy as a defense against competitors, both business and technical. It is a two edged sword.

Immediately Tesla worked to complete the electrical design. In early 1901 he set about ordering generators and transformers from Westinghouse Electric and acquiring land on Long Island. The open farmland he selected was at Shoreham, about 75 miles east of Manhattan. Purchased from a James S. Warden, the site was named Wardenclyffe. Tesla engaged his friend, architect Stanford White, to design the principal building and a colleague of White, W.D. Crow, to design the tower.

For most of 1901 Tesla lived near the site and supervised every detail. The White building was completed and the tower was rising. It would be 187 feet above the ground with a well 12 feet square and 120 feet deep as an integral part of the design.

The year was coming to a close and two important problems arose. The electrical equipment was distressingly overdue and Marconi signaled the letter "S" from England to Newfoundland on December 12th using equipment only a fraction of the complexity being prepared at Wardenclyff! Now, the full reach of Tesla's vision was coming to light. He was planning to use Wardenclyffe to transmit electric power to any point on earth without wires! Success would be the most important technical achievement of the age. Even failure would be valiant, but what of the practical aspect for which the tower had been funded?

Construction continued through 1902, more than a year beyond the timetable agreed to with J.P. Morgan. In early 1903 the 68-foot diameter wooden spherical cage atop the tower was nearing completion. This ball was to be sheathed in copper, but funds were running out and many creditors were still to be paid. It was obvious that more funding would have to be raised if the tower was to be made functional. Tesla wrote Morgan several times that spring for additional funds. Finally, Morgan replied on July 14, 1903 with a firm "No."

Morgan's reputation for an eye for a good deal, and his refusal to invest more with Tesla plus a Wall Street panic in the fall of 1903 made raising more funding impossible. His longtime benefactor, Thomas Fortune Ryan, invested some additional money to pay creditors, but no new funds were available for the tower. Effectively, this was the end of the Wardenclyffe tower.

In 1915, Tesla turned the deed to the Wardenclyffe property over to the Waldorf-Astoria hotel for $20,000 in unpaid hotel bills. The tower was demolished for salvage in 1917. A predecessor of the current occupant, Peerless Photo Products, a subsidiary of the Belgian photo company, Agfa-Gevaert, acquired 15 acres of the property in 1939. I visited the site in September 1983 for a reception hosted by Agfa-Gevaert to receive a presentation of the Nikola Tesla U.S. commemorative postage stamp. Peerless Photo was still in operation at that time. The White building, bearing a bronze historical plaque, was in good shape and being used for storage. The eight concrete foundations of the original tower are clearly visible about 60 or 70 feet to the right of the White building. The 120-foot deep well appears to have been filled in, perhaps to remove it from being an attractive hazard to trespassing children.

CURRENT STATUS

Some years ago, perhaps as many as ten, Agfa-Gevaert terminated operations at Peerless Photo. Before any disposition of the property can be made, Agfa must clean up the ground contaminated from years of photochemical manufacturing by Peerless Photo. The cleanup program must be approved and monitored by the Department Environmental Conservation (DEC). Agfa has made an assessment of the problem and begun preparing remediation plans for the DEC. The cleanup program is not a critical issue for Agfa as the property is fenced and guarded.

The Shorham School District maintained a science museum at the Wading River High School. The Museum Accreditation Association advised the District that they would need more room. The Agfa property looked inviting both for availability and its historical significance. To pursue this end, the museum board set up a not for profit corporation, Friends of Science East (Friends/East), in 1996.

The intricacies of not for profit corporation regulations effectively preclude Friends/East from accepting title to this property, should it be offered. The nearby Town of Brookhaven was approached with the idea of a science museum on the Agfa property. With Friends/East to run the museum, a large quantity of photo exhibits and Tesla memorabilia available from the Tesla Wardenclyffe Project and the support of the Town, the idea was presented to Agfa. The result on Agfa's side has been positive – though in no way a certainty. Donation of the property represents a viable alternative for Agfa with favorable community goodwill.

(The Tesla Wardenclyffe Project was incorporated about the same time as Friends/East with the aim of founding a Tesla museum on the Wardenclyffe site and preserving the Stanford White building. They purchased the large Leland Anderson collection of Tesla photographs and have joined with Friends/East in the Agfa museum site.)

There is a substantial level of interest for a museum at the Agfa Tesla site. The Town of Brookhaven declared July 10, 2003 as Nikola Tesla Day, issued a Proclamation and held a reception with multiple speakers. They intend to declare each July 10 Nikola Tesla Day at least until 2006, Tesla's 150th Birthday. Several other nearby communities have joined in recognizing Tesla and supporting a museum on the Agfa site. Brookhaven National Laboratories, one of the Nation's leading science institutions, is located in the immediate area and could be a source technical speakers and exhibits.

Acknowledgements to Leland I. Anderson for history and Marianne Macy for current status assists.

William H. Terbo 9 November 2003 © 2003 WHT/tmsrd

TESLA ENERGY SCIENCE CONFERENCE

BOOKS

A great deal has been written by and about Nikola Tesla from the time he arrived in America in 1884, through his life and continuing to the present. The volume over time has depended on his level of fame at each period in his life or in the more recent recognition of the importance of his inventions and the intriguing aspects of his philosophy and personality.

At the height of his fame from 1890 to about 1910, the volume was staggering. *The Tesla Collection* (sponsored by the Tesla Memorial Society) contains 4,500 pages of unduplicated material covering the period from 1885 to 1920. As Tesla was a darling of the popular press, the majority of items are from the ten New York daily and Sunday newspapers. But also included is a wealth of serious and technical items from scientific and professional publications. Nikola Tesla himself wrote at least 66 significant articles and lectures between 1887 and 1934 plus the series of articles in 1919 that made up his autobiography *My Inventions*.

In trying to sort out a relatively brief list of titles from my personal library of 100 or more "Tesla" books, I've tried to organize them into categories from the earliest to the most recent entries. For anyone wishing to write a biography, novel (or term paper) about Nikola Tesla need only the following four titles to provide the basic "Tesla" research:

- *My Inventions*, The Autobiography of Nikola Tesla (1919), Ben Johnson, Editor, 1982, Hart Brothers (111pages). The series of six articles published between February and October 1919 in the magazine Electrical Experimenter with a new, informative and perceptive Introduction by Ben Johnson.
- *Prodigal Genius*, The Life of Nikola Tesla, John J. O'Neill, 1944, Ives Washburn (326 pages). A mixture of fact and fiction with few footnotes and no bibliography to distinguish between the two. O'Neill, a believer in spiritualism and psychic powers, rushed the book into print and suggested, in a manner, that his friend, Tesla, also had such powers. This book, cited by many later writers, is primarily responsible for much of the mythology that surrounds Tesla's name today.
- *The Complete Patents of Nikola Tesla*, Jim Glenn, Editor, 1994, Barnes & Noble Books (535 pages). Almost more than you need to know with helpful Introductions by Jim Glenn.
- *Tesla, Man Out Of Time*, Margaret Cheney, 1981, Prentice-Hall (320 pages). A carefully researched work, both historically and technically, that caught the wave of new interest in Tesla, the man. More than 200,000 in print and translated into several languages included Japanese and Korean.

To write a new biography of the whole life of Nikola Tesla, one that will supplant existing work such as Margaret Cheney's *Man Out Of Time*, will require a prodigious amount of research and dedication. The alternative is to address a situation in which

Tesla played a pivotal role – to create a dramatic "hook" upon which the author can find a market for a new work that includes meeting the public thirst for more information about this enigmatic, reclusive giant whose scientific contributions are being more commonly known.

I have tried to make myself available to as many authors and playwrights as seek my assistance. By doing so, I hope to correct some of the errors that have been perpetuated by reliance on flawed research material. Currently, I'm dealing with at least half dozen writers who are moving forward on Tesla projects. Whether any new books or scripts from this effort will actually see the light of day is yet to be determined.

A number of new books have reached the market in the past year or two. Each relies on a "hook" to include a major and necessary sketch of Tesla, his personality and his participation in the subject at hand. While all include significant research on all aspects of the theme being examined, some have fallen back on the "easy" Tesla research described above. Among the most prominent are:

- *Empires of Light*, Jill Jonnes, 2003, Random House (416 pages). The "hook" is in the subtitle: Edison, Tesla, Westinghouse, and the race to electrify the world. Ms. Jonnes treats Tesla very kindly and with great sympathy, acknowledging every element of the Tesla AC system that won the day for Westinghouse. She also deals directly with Edison's obstructionism in defending his DC system. Westinghouse is very favorably characterized as the (unusual) model of a moral industrial tycoon. I watched an hour interview of Ms. Jonnes on a very recent C-SPAN *Booknotes* program. I squirmed as she failed to answer almost any question concerning the details of book as put to her by Host Brian Lamb. (She did remember the date of the electrocution of axe murderer, William Kemmler.) It appears she left the 2-year writing effort on the page and not in her head.
- *The Devil in the White City*, Erik Larson, 2003, Crown Publishers (447 pages). The "hook" is the creation of the 1893 Columbian Exposition "White City" from the swampy Jackson Park while a serial killer built a "World's Fair Hotel" nearby where scores of young women were tortured, killed and cremated. Mr. Larson examines the intrigue of Chicago politics surrounding the contracts for building the "White City" and the detective work (albeit too late) of catching the killer. The contest between General Electric and Westinghouse to light the Exposition is a part of the story – and Westinghouse's Tesla patent victory "helped change the history of electricity."
- *Nikola Tesla, The European Years*, D. (Dan) Mrkich, 2003, Commoner's Publishing, Ottawa (143 pages). Most Tesla writing deals with the romance of his American years of invention, success and frustration with only a superficial nod to his earlier years usually gleaned from his autobiography. Mr. Mrkich has provided important new research that fills in details that Tesla omitted (or may have chosen to ignore) in later writings. He has visited every site (and every building, if still standing) and every source of records where Tesla lived, was educated and worked. In addition to sites in the former Yugoslavia, these locations include Graz , Prague, Budapest, Paris and Strasbourg. Among the new

information revealed was his work in Maribor, Slovenia, where he worked as a common draftsman during the time he was avoiding University and his parents. I consulted with Mr. Mrkich and had the honor of writing the Foreword to *The European Years*.

- *Nikola Tesla, Tagebuch Aus Strassburg (Journal From Strasbourg)*, 2002, Nikola Tesla Museum, Belgrade (251 pages, German and Serbian). The Journal covers the correspondence with Paris Edison Company (and an accounting of every Mark and Franc spent) for the year 1883-84 while Tesla repaired the Edison lighting system which had blown up in the presence of the Kaiser at its dedication. The Journal shows that Tesla could be an effective manager as well as a talented engineer.
- Executioner's Current, Richard Moran, 2002, Alfred A. Knopf (271 pages). The story of how Thomas Edison's contribution to the American criminal justice system was born out of corporate greed. Edison's attempt to make George Westinghouse into America's Dr. Guillotine is a damning contradiction of the folksy image of this "Icon of Electricity." While Tesla's involvement in this contest is minor, his technology is paramount. Recently, I listened to a long NPR radio interview with Mr. Moran. When asked at the end of the interview what other thoughts he had about his book, Mr. Moran launched into a laudatory stream about his regard for Nikola Tesla. There is a contagion for writers when confronted with the personality of Tesla.
- *Harnessing the Wheelwork of Nature*, Thomas Valone, Editor, 2002, Adventures Unlimited Press (338 pages). A collection of articles (many not published before) dealing with Tesla's Science of Energy, with a lengthy Introduction to correlate the collection.
- *The Man Who Invented the Twentieth Century*, Nikola Tesla, Forgotten Genius of Electricity, Robert Lomas, 1999, Headline Book Publishing, London (248 pages). The "hook" is the approach to Tesla's life and business decisions through the "money trail" and is ingenious and almost unique among the many other Tesla biographies. Dr. Lomas lectures in Engineering Management, is a lifelong enthusiast for Tesla and teaches his student how NOT to run their business affairs.
- *Tesla, Master of Lightning*, Margaret Cheney & Robert Uth, 1999, Barnes & Noble Books (184 pages). The Companion Book for the 90-minute PBS television biography *Master of Lightning* and the best publication available for a sketch of the complete Tesla. Illustrated with over 200 photos, illustrations and drawings.

These are a few additional books and publications that deserve to be mentioned for historical value or specific target audiences:

- *Nikola Tesla*, Memorandum book on the occasion of his 80th anniversary, 1936, Institute Nikola Tesla Foundation, Belgrade (520 pages). Birthday greetings from every corner of the world and Proceedings of a Conference on Tesla Technology accompanying the anniversary celebration. For example, a portion of the congratulations from Ernest Rutherford of Cambridge "I was greatly

impressed in my younger days by his experiments on high frequency currents. I have often made use of the Tesla transformer as a method of producing high voltages in my researches."

- *Lightning In His Hand*, The Life Story of Nikola Tesla, Inez Hunt and Wanetta W. Draper, 1964, Omni Publications (269 pages). A successful biography at the low point of Tesla's fame.
- *Light and other High Frequency Phenomena*, Nikola Tesla, 1893, National Electric Light Association (114 pages). An original copy of an historic Tesla lecture.
- *Priority in the Invention of Radio, Tesla vs. Marconi*, Leland Anderson, 1980, Antique Wireless Association (article, 9 pages). Chapter and verse citing Tesla priority through lectures, patents, experiments and the findings of the U.S. Supreme Court.
- *Nikola Tesla, Colorado Springs Notes 1899-1900*, Scientific Commentaries by Aleksandar Marincic, 1978, NOLIT / Nikola Tesla Museum, Belgrade (437 pages). Tesla's notes organized, interpreted and defined by Dr. Marincic.
- *Nikola Tesla, Correspondence with Relatives*, 1993, Nikola Tesla Museum, Belgrade (397 pages). English version, translated by Nicholas Kosanovich, 1995, Tesla Memorial Society (200 pages). Of particular interest to me as over one-third of the correspondence is between Tesla and my father, Nikola Trbojevich, also a prominent scientist and inventor.
- *The Streams of Lenard and Roentgen and Novel Apparatus for Their Production*, Nikola Tesla: Lecture before the New York Academy of Sciences – April 6, 1897, Leland I. Anderson, Editor, 1994, Twenty First Century Books (123 pages). A lecture that went far beyond the title with editorial discussion of departures by Mr. Anderson.
- *Nikola Tesla, A Spark of Genius*, Carol Dommermuth-Costa, 1994, Lerner Publications (144 pages). Latest and best of a number of Tesla biographies for younger students.
- *Tesla*, Tad Wise, 1994, Turner Publishing (381 pages). "A biographical novel of the world's greatest inventor."
- *Wizard*, The Life and Times of Nikola Tesla, Marc J. Seifer, 1996, Birch Lane Press (542 pages). In addition to a biographical narrative, Dr. Seifer, a noted handwriting expert, examines the stress of relationships between Tesla and many of his business contemporaries. I consulted with Dr. Seifer and had the honor to write the Foreword to *Wizard*.
- *Nikola Tesla, Guided Weapons & Computer Technology*, Leland I. Anderson, Editor, 1998. Twenty First Century Books (241 pages). Tesla's patented development of the first radio remote controlled device, a boat demonstrated to the public in 1899, also resulted in one of the fundamental building blocks of circuit and computer design, the computer AND gate

TESLA ENERGY SCIENCE CONFERENCE

VIDEO DOCUMENTARIES

The best way to educate the general public about Tesla his accomplishments and persona is through the mass media. Television is the medium of choice. It is "hot" and reaches the largest number of people. Radio reaches large numbers but it's "cool." Books and newspapers involve people but the numbers are smaller – and they are "cool." The Tesla Memorial Society supports documentary production companies with photos, memorabilia, advice, contacts and on-camera interviews. Such cooperation often bears fruit. By providing the best and most dramatic Tesla photos, promos for the upcoming documentaries will feature more images of Tesla than of other participants.

I've just picked the most recent documentaries featuring Tesla. My experience is that an introduction to Tesla for producers, writers and directors makes them fans and inspires them to do their best. Tesla is addictive!

- *Battle of the Currents*, Engstfeld Film GmbH, Germany, 2004, 45 minutes, German; 52 minutes, French; 52 minutes English. The first of a 4-part series on invention. (The other parts address Goodyear and vulcanizing rubber, radar and the submarine.) This is a well-funded project. (They came to the U.S. from Germany with a 7-person crew.) The video is in post-production now and scheduled for network release in autumn, 2004. The U.S. network is to be the Discovery Channel. I've had multiple contacts with the producer and believe the thrust of the documentary strongly favors Tesla. My two-hour on-camera interview took place beside Edison's desk at the Edison National Historical Site in West Orange, New Jersey. If experience is any measure, I will appear for one minute or less.
- *Nikola Tesla*, Fontis TV Production, Czech Republic, 2002, 22 minutes, Czech. The Czech Ministry of Education became aware that very few students were aware of Tesla, who was educated in Prague, and his contributions to modern society. The video is to be shown to Czech students at the High School level. The 3-person Fontis crew shot at my home, five locations in Manhattan and Niagara Falls, America and Canada. I did another 2-hour on-camera interview for Fontis and introduced the Manhattan sites.
- *The Top 15 Inventors of the 20th Century*, Kralyevich Productions for the Arts & Entertainment Networks, 2002, 59 minutes. *Inventors* was one of a series of A&E programs celebrating the 15th anniversary of their *Biography* series. Tesla was ranked 7th, which I thought was about right **for inventions patented in the 20th Century!** (Experts praised Tesla much more than befits a #7 ranking.) The concept was flawed in that inventors were included who had no inventions (Ford #12), or that patented nothing of note in the 20th century (Edison #1) while excluding inventors who patented before 1900 (Alexander Graham Bell). Again, I did a 2-hour interview in a Manhattan studio for 30 seconds face time.
- *In Search Of ...*, KAOS Entertainment for Fox Television, 2001, originally 50 minutes. Originally one of eight segments shot for a return of the long running

series bought by Fox. When the return was canceled, the segments were sold, first to the UPN Network and ultimately to the SciFi Channel where it appeared in an 18-minute version with two other segments. My 2-hour on-camera interview resulted in a few seconds of face time (plus some voice-over.)

- *Tesla, Master of Lightning*, New Voyage Communications for PBS Television Network, 2000, 90 minutes. This is the standard for Tesla biographies to date. The producer, Robert Uth, spent time on the details and had full use of important archival materials from several sources. In addition to several showings on PBS TV, the video is available to schools through the PBS Educational Co-op Program. My 2-hour on-camera interview resulted in considerable face time.

The Society has cooperated with many other documentary producers over the past four or five years. Tesla has been featured in British, Japanese, Australian and Danish videos in addition to U.S. network and cable outlets like ABC, The Learning Channel and PBS.

The commercial film *The Secret of Nikola Tesla*, starring Petar Bozovic (as Tesla), Orson Welles (as J.P. Morgan), Strother Martin (as Westinghouse) and Dennis Patrick (as Edison) was produced in 1981 in the former Yugoslavia (in English). In spite of excellent production values, it treated Tesla with too much reverence, stifling the dramatic possibilities. Since then at least a dozen new films have been announced with none yet arriving on the screen. Famous directors and famous actors have been named without a film being started, much less being finished.

William H. Terbo 9 November 2003 © 2003 WHT/tmsre



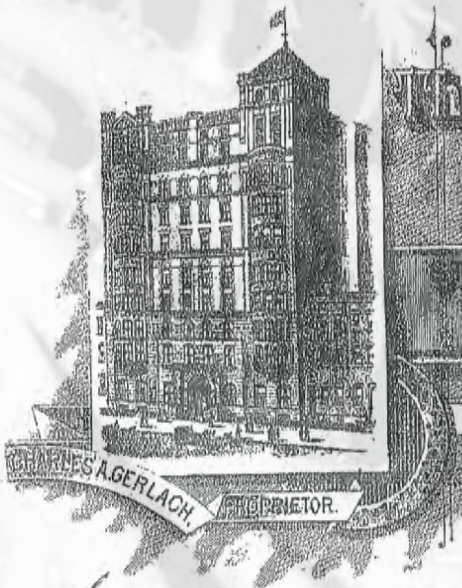
A/3/18

New York March 12 1893

Dear M. Adams,

Although I have had exchange of thoughts with you in regard to your favor of Feb. 23d. I consider it necessary to express myself quite clearly and by letter in regard to that subject.

The patent of Thomson No. 363,186, to which reference is made, has absolutely nothing to do with my discovery of the rotating magnetic field and the radically novel features of my system of transmission & power disclosed in my foundation patents of 1888. All the elements shown in the Thomson patent were well known and had been used long before by a number of



New York, 189

In this reference is likewise made
I would think it fair to all
concerned that a thorough examination
be made of their history and bearing.
Such examination, which has been
made by myself without the slightest
prejudice, will convince you that
in the earliest patent there is not
the least hint of a method of
transmission of power which would
be useful, or of devices which
could not have been described
before. As regards the later
patents they are plainly covered
by my fundamental claims.
Engineers all beginning now to



New York, Jan. 9 1893

Dear Mr. Adams,

Last night in going with Mr. White over the clean specification of Prof. Hewitt I noted that Prof. Hewitt wishes the speed of the fabric to be about 150 rev. I thought it barely possible that all the details have not been explained to him and that consequently he might not be aware of some bad disadvantages resulting from the low speed. For instance from the sketch you showed me I understood, that the distance between the roll and Dynamo was only 8-10 feet on the assumption, that the Dynamo had a diameter of something like 19 ft. Now I believe that in the design of Mr. Schmid

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Letter from Nikola Tesla to Edward Dean Adams dated January 9, 1893
Draft of text handwritten on Gerlach Family Hotel stationary (italics to show indistinct writing)

(First handwritten page)

New York Jan. 9 1893 (bold preprinted on Hotel stationary)

Dear Mr. Adams,

Last night in going with Mr. White over the *clear* specification of Prof. *Xxxx*'s I noted that Prof. *Xxxx*'s wishes the speed of the turbine to be about 150 rev. I thought it barely possible that all the details have not been explained to him and that consequently he might not be aware of over-*load* disadvantages resulting from the load speed. For instance from the sketch you showed me I understood, that the distance between the wall and the dynamo was only 8-10 feet on the assumption, that the dynamo had a diameter of something like 19 feet. Now I believe that in the design of Mr. *Schmid*

(Second handwritten page)

the dynamo is of very nearly the above diameter on the assumption that the speed of the turbine is 250 rev. If you would reduce the speed it would necessitate, if proper rules of construction are observed, that the diameter of the dynamo be made considerably larger, which would leave still a smaller space between the wall and the machine, and this I think, with such *significant machinery* which will be viewed by *Morivands*, would be decidedly bad. Of course, I need not say that such a low speed dynamo would cost much more. I am of the opinion that you should consider this, so much the more, as Prof. *Xxxx*'s does not lay particular stress upon the low speed but surely would prefer it if it were practicable. Even with 250 rev. the dynamo is, to be sure, large enough.

Kindly consider this communication and others which I may make entirely personal as I would not run the risk of offending Prof. *Xxxxx*, whom I highly esteem:

Yours sincerely
N Tesla.

WHT/tmsxa

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Letter from Nikola Tesla to Edward Dean Adams dated February 2, 1983
Draft of text handwritten on plain stationary (italics to show indistinct writing or clarification)

(First handwritten page)

Feb. 2, 1893

Dear Mr. Adams,

Your fav. *(favor)* has just reached me. The danger when working unattended is not as great as you may suppose. I have been constantly at work with currents up to a quarter million volts for two or three years past and have met with only one accident. Of all forms of energy harnessed in the service of man, that of electricity is certainly the least dangerous were it only on account of the fact that but a single person can be injured at a time.

I have not as yet heard from Germany but I have not the slightest doubt that all Companies except Helios, who have acquired the rights from my Company will have to stop the manufacture of phase motors. Proceedings against the infringers

(Second handwritten page)

have been taken in the most energetic way by the Helios Co. It is for this reason that our enemies are driven to the single phase system and rapid changes of opinion.

In regard to your query about synchronous motors I would say that the motors will run in exact synchronism with the generator in spite of any number of transformations. We can also make according to my patents changes in the speed as we like. For instance the motor may be made to run at any fraction (within certain limits) or multiples of the speed of the generator. This feature is valuable in the general distribution. I would also say, that besides synchronous forms of motor we have also such as required for the operation of devices requiring great effort but not constant speed, as for instance, cranes e.t.c.

That the phase system is not yet in extensive operation is due merely to circumstances of which you are aware to some extent. A number of motor plants have been put in mines where they have given the utmost satisfaction. There is no danger that the phase system will be superceded *(variant of superseded)* by the single current system. The advantages of the former are to *(sic)* great. Next time I have the pleasure to meet you I will show you the reasons.

Sincerely yours
N Tesla.

P. S. Please kindly excuse this hasty communication. *(Written vertically in the left-hand margin of second page)*

WHT/tmsxb

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Letter from Nikola Tesla to Edward Dean Adams dated February 6, 1893
Draft of text handwritten on plain stationary (italics to show indistinct writing or clarification)

(First handwritten page)

Feb. 6, 1893

Dear Mr. Adams,

I thank you for your attention shown by your letter of the 4th inst. which has reached me in due course together with enclosures which I herewith return.

In regard to the article you had the kindness to call to my notice I would say that the writer has expressed a number of times quite opposite views. I have been sorry to find his contributions as a rule so weak, that it was quite impossible for me to comply with scientific courtesy by answering them. The plan proposed by him is many years old and has been repeatedly tried especially at the debut of the alternating system, but was found impracticable. I would want to have a longer

(Second handwritten page)

talk with you to explain some details and you would at once see the absurdity of the plan. Were it at all practicable I could prove at any time that my system would offer a saving of 40% - 50% over his.

I have to tell you the term "multiphase motors" comprises 3 distinct forms of my motors: 1) Non synchronous (used at *Lauffen*) 2) Synchronous but entirely alternating 3) Synchronous with field – directly *excited*. All criticisms apply only to the first two forms. In both forms the highest efficiency can be reached, and their only defect is that the current is somewhat larger than it ought to be in a perfect machine. This defect, however, does not amount to anything in ordinary practice as it may be made to disappear entirely. To illustrate, we only need to raise the e.m.f. 25% and we save on copper even against the direct current system.

(Third handwritten page)

Objections as to the current have therefore no weight, as it is much easier to run a machine which has no commutator or brushes with an e.m.f. 25% higher than a direct current machine with an adequately smaller e.m.f. Not to speak of the advantages which the ideal simplicity of these machines affords in the long run.

Under frequent conditions in practice it would be entirely impossible for any system to compete this ideally simple one; but I must say that again under different conditions a better solution is possible. This is the third form of my motor. This form

has never been criticized by the adversaries of my system and for a good reason, because it is the most efficient form of electric machine that has been produced to this day. I have shown that on such machines under favorable conditions an efficiency of 97% can be obtained. In output per weight it can be equaled

(Fourth handwritten page)

by no machine whatever, direct or alternating. It also possesses the ideal feature of running in absolute synchronism with the generator, while it has a good starting *figure*. This is the type of machine you have seen and which the W. Co *(assume Westinghouse Company)* propose to use for large units. You need not think that this form of machine has not been thoroughly tried. This machine merely is equivalent to two or three synchronizing machines coupled. A saving of expense and numerous practical advantages of *vital importance* is the result For large units, especially, it would be utterly impossible for any system to compete with this. The advantages of *this* system are so great that even had we today a perfect alternating current motor requiring two wires, the system would have to be introduced just as soon as it comes to *earning* dividends *on* the capital. The three wire system offered to the direct current distribution *comprising* very small advantages, yet the three wire system was adopted. But what is recognized merely an advantage in direct current distribution will become dire necessity in the alternating system.

(The following written vertically in the left-hand margin of the fourth page)

Sincerely yours
N Tesla

Excuse haste

WHT/tmsxc

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Letter from Nikola Tesla to Edward Dean Adams dated March 12, 1893
Draft of text handwritten on Gerlach Family Hotel stationary (italics to show indistinct writing or clarification and bold to show text underlining)

(First handwritten page)

New York, March 12 **1893** (bold preprinted on Hotel stationary)

Dear Mr. Adams,

Although I have had exchange of thoughts with you in regard to your fav. (favor) of Feb. 23rd I consider it necessary to express myself quite clearly and by letter in regard to that subject.

The patent of Thomson Nr. 363.186, to which reference is made, has absolutely nothing to do with my discovery of the rotating magnetic field and the radically novel features of my system of transmission of power disclosed in my foundation patents of 1888. All the elements shown in the Thomson patent were well known and had been used long before by a number of

(Second handwritten page)

experimenters. I myself exhibited devices early in 1887, but I was not encouraged to work in that direction as I found that the motor was very inefficient and that the commutator and brushes caused trouble. I showed in my patents that alternating motors could be run without the employment of a commutator and I produced an efficient and practical motor, which I was able to run either on multiple or single alternating circuits. In fact, one of the many reasons why I advocated the adoption of two phase currents rather than three phase shown in my patents was, that a two phase motor was better *suitable* for single or ordinary *existing* circuits and that it could be operated on these circuits with fair efficiency, though smaller than that obtained by the use of multiple supply circuits. Some engineers do not realize this even today.

As to the *Bradley* patents,

(Third handwritten page – on Hotel letterhead stationary)

to which reference is likewise made, I would think it fair to all concerned that a thorough examination be made of their history and bearing. Such examination, which has been made by myself without the slightest prejudice, will convince you that in the earliest patent there is not the least *hint* of a method of transmission of power which would be novel, or of devices which would not have been described before. As regards the later patents they are plainly covered by my fundamental claims.

Engineers are beginning now to

(Fourth handwritten page)

notice that the *earning* capacity of an alternating plant with currents of **more than one** phase is much greater and that we are forcibly driven to introduce in our alternating systems of distribution multiple circuits. Some think that a perfect alternating motor, to be *on one* single circuit, could satisfy all needs. In reality such a motor would have a very limited value in a year or two, when, in consequence of competition the necessity will rise to use more than one circuit. The direct systems had to go through such a process merely for the sake of saving some copper, and their engineers had to make extensive changes and considerably complicate the systems at that.

Yours sincerely
N. Tesla.

P. S.
Thanks for the clippings received.

WHT/tmsxd

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Note from Nikola Tesla to Edward Dean Adams dated March 22, 1893
Draft of text handwritten on 5 x 8 inch lined notepaper (italics to show indistinct writing or clarification and bold to show text underlining)

(First handwritten sheet)

New York March 22. 1893.

Dear Mr. Adams,

Your fav. *(favor/letter)* received. I forward copy of "Electrician" of Aug. 5.
The writers of these articles are absolutely unacquainted (that is they were) with some facts. For instance they do not know that by merely winding the motor in a certain way absolute constancy of the field is obtained with two phases, so that it is the same as far as this is concerned

(Second handwritten sheet)

whether there are *two* or a million phases. But the gravest error the Authors make is that they express the belief that the constancy of field is important for the efficiency of the motor. In my earlier work I thought so and constructed motors with many phases. You will find in going over my writings and patents that I have before advanced all these views, and what these writers state in this journal is merely a repetition of what I have shown or stated. But I convinced myself that it is not im-

(Third handwritten sheet)

portant at all to have the field constant. The chief importance in an alternate current motor rests upon the *intimate* magnetic connection between the field and armature coils, as I have pointed out long ago. But even the closure of the magnetic circuit must be influenced by practical considerations. For instance some of my first motors I made with holes in the armature and field in order to close the magnetic circuit more completely. This *causes* some disadvantages when the machine is worked

(Fourth handwritten sheet)

directly, also when it is operated from a transformer (more or less). We found that for each motor, according to what it is built for, certain rules of construction had to be followed. On this entire books can be written. Even presently there are perhaps one half a dozen Engineers who know fairly well this subject.

I have to advise you to accept the two phase plan, though it would be much more for my personal interest if you would decide for the three phase. I shall explain this to you when I next have the pleasure of meeting you.

Yours sincerely

N Tesla.

Excuse in haste

WHT/tmsxf



New York March 12 1893

Dear Mr. Adams,

Although I have had exchange of thoughts with you in regard to your favor of Feb. 23d. I consider it necessary to express myself quite clearly and by letter in regard to the subject.

The patent of Thomson No. 363,186, to which reference is made, has absolutely nothing to do with my discovery of the rotating magnetic field and the radically novel features of my system of transmission of power disclosed in my foundation patents of 1888. All the elements shown in the Thomson patent were well known and had been used long before by a number of

experimenters. I myself exhibited such devices early in 1887, but when I was encouraged to work in that direction and I found that the motor was very inefficient and that the commutator and brushes caused trouble. I showed in my patents that alternating motors could be run without the employment of a commutator and I pointed out efficient and practical motors which were able to run either on multiple or single alternating circuits. One fact, one of the many reasons why I advocated the adoption of two phase currents rather than three phase shown in my patents - was, that a two phase motor was better suitable for single or arbitrary alternating circuits and that it could be operated on these circuits with fair efficiency, though smaller than that obtained by the use of multiple supply circuits. Some engineers do not realize this even to-day.

As to the Brady patents,



New York, _____ 189_

In this reference is likewise made
I would think it fair to all
concerned that a thorough examination
be made of their history and bearing.
Such examination, which has been
made by myself & I think the slightest
prejudice, will convince you that
in the earliest patent there is not
the least hint of a method of
transmission of power which would
be useful, or of devices which
could not have been described
before. As regards the later
patents they are plainly covered
by my fundamental claims.
Engineers are beginning now to

realize that the earning capacity of an alternating plant with currents of more than one phase is much greater and that we are forcibly driven to introduce in our alternating systems of distribution multiple circuits. Some think that a proper alternating motor, to be run on single circuit, would satisfy all needs. In reality such a motor would have a very limited value in a year or two, when, in consequence of completion the necessity will arise to use more than one circuit. The direct systems had to go because such a person never for the sake of saving some copper, and their engineers had to make expensive changes and considerably complicate the systems at that.

Yours very

N. Tesla.

P. S.

Thanks for clippings received.



New York, Jan. 9 1893

Dear Mr. Adams,

Last night I going with Mr. White over the clean specification of Prof. Hunt's I noted that Prof. Hunt wishes the speed of the turbine to be about 150 rev. I thought it barely possible that all the details have not been explained to him and that consequently he might not be aware of some bad disadvantages resulting from the low speed. For instance from the sketch you showed me I understood, that the distance between the wall and flywheel was only 8-10 feet on the assumption, that the flywheel had a diameter of something like 19 ft. Now I believe that in the design of Mr. Schmidt

The dynamo is I may nearly be above diameter on the assumption that the speed of the turbine is 250 rev. If you were to reduce the speed it would necessitate, if proper results of construction are observed, that the diameter of the dynamo be made considerably larger, which would leave still a smaller space between the wall and the machine, and this I think, with such magnificent machinery which will be driven by Niagara, would be decidedly bad. Of course, I need not say that such a low speed dynamo would cost much more. I am of the opinion that you should consider this, so much the more, as Prof. Unwin does not lay particular stress upon the low speed but merely would prefer it if it were practicable. Even with 250 rev. the dynamo is, to be sure, large enough.

Kindly consider this communication and others which I may make entirely private as I cannot but warn the city of Buffalo Prof. Unwin, whom I highly esteem.

Yours very truly
Nikola Tesla.

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Letter from Nikola Tesla to Edward Dean Adams dated January 9, 1893
Draft of text handwritten on Gerlach Family Hotel stationary (italics to show indistinct writing)

(First handwritten page)

New York Jan. 9 **1893** (bold preprinted on Hotel stationary)

Dear Mr. Adams,

Last night in going with Mr. White over the *clear* specification of Prof. *Xxxx*'s I noted that Prof. *Xxxx*'s wishes the speed of the turbine to be about 150 rev. I thought it barely possible that all the details have not been explained to him and that consequently he might not be aware of over-*load* disadvantages resulting from the load speed. For instance from the sketch you showed me I understood, that the distance between the wall and the dynamo was only 8-10 feet on the assumption, that the dynamo had a diameter of something like 19 feet. Now I believe that in the design of Mr. *Schmid*

(Second handwritten page)

the dynamo is of very nearly the above diameter on the assumption that the speed of the turbine is 250 rev. If you would reduce the speed it would necessitate, if proper rules of construction are observed, that the diameter of the dynamo be made considerably larger, which would leave still a smaller space between the wall and the machine, and this I think, with such *significant machinery* which will be viewed by *Morivands*, would be decidedly bad. Of course, I need not say that such a low speed dynamo would cost much more. I am of the opinion that you should consider this, so much the more, as Prof. *Xxxx*'s does not lay particular stress upon the low speed but surely would prefer it if it were practicable. Even with 250 rev. the dynamo is, to be sure, large enough.

Kindly consider this communication and others which I may make entirely personal as I would not run the risk of offending Prof. *Xxxxx*, whom I highly esteem:

Yours sincerely
N Tesla

WHT/tmsxa

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Letter from Nikola Tesla to Edward Dean Adams dated February 2, 1983
Draft of text handwritten on plain stationary (italics to show indistinct writing or clarification)

(First handwritten page)

Feb. 2, 1893

Dear Mr. Adams,

Your fav. *(favor)* has just reached me. The danger when working unattended is not as great as you may suppose. I have been constantly at work with currents up to a quarter million volts for two or three years past and have met with only one accident. Of all forms of energy harnessed in the service of man, that of electricity is certainly the least dangerous were it only on account of the fact that but a single person can be injured at a time.

I have not as yet heard from Germany but I have not the slightest doubt that all Companies except Helios, who have acquired the rights from my Company will have to stop the manufacture of phase motors. Proceedings against the infringers

(Second handwritten page)

have been taken in the most energetic way by the Helios Co. It is for this reason that our enemies are driven to the single phase system and rapid changes of opinion.

In regard to your query about synchronous motors I would say that the motors will run in exact synchronism with the generator in spite of any number of transformations. We can also make according to my patents changes in the speed as we like. For instance the motor may be made to run at any fraction (within certain limits) or multiples of the speed of the generator. This feature is valuable in the general distribution. I would also say, that besides synchronous forms of motor we have also such as required for the operation of devices requiring great effort but not constant speed, as for instance, cranes e.t.c.

That the phase system is not yet in extensive operation is due merely to circumstances of which you are aware to some extent. A number of motor plants have been put in mines where they have given the utmost satisfaction. There is no danger that the phase system will be superceded *(variant of superseded)* by the single current system. The advantages of the former are to *(sic)* great. Next time I have the pleasure to meet you I will show you the reasons.

Sincerely yours
N Tesla

P. S. Please kindly excuse this hasty communication. *(Written vertically in the left-hand margin of second page)*

WHT/tmsxb

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Letter from Nikola Tesla to Edward Dean Adams dated February 6, 1893
Draft of text handwritten on plain stationary (italics to show indistinct writing or clarification)

(First handwritten page)

Feb. 6, 1893

Dear Mr. Adams,

I thank you for your attention shown by your letter of the 4th inst. which has reached me in due course together with enclosures which I herewith return.

In regard to the article you had the kindness to call to my notice I would say that the writer has expressed a number of times quite opposite views. I have been sorry to find his contributions as a rule so weak, that it was quite impossible for me to comply with scientific courtesy by answering them. The plan proposed by him is many years old and has been repeatedly tried especially at the debut of the alternating system, but was found impracticable. I would want to have a longer

(Second handwritten page)

talk with you to explain some details and you would at once see the absurdity of the plan. Were it at all practicable I could prove at any time that my system would offer a saving of 40% - 50% over his.

I have to tell you the term "multiphase motors" comprises 3 distinct forms of my motors: 1) Non synchronous (used at *Laiffen*) 2) Synchronous but entirely alternating 3) Synchronous with field – directly *excited*. All criticisms apply only to the first two forms. In both forms the highest efficiency can be reached, and their only defect is that the current is somewhat larger than it ought to be in a perfect machine. This defect, however, does not amount to anything in ordinary practice as it may be made to disappear entirely. To illustrate, we only need to raise the e.m.f. 25% and we save on copper even against the direct current system.

(Third handwritten page)

Objections as to the current have therefore no weight, as it is much easier to run a machine which has no commutator or brushes with an e.m.f. 25% higher than a direct current machine with an adequately smaller e.m.f. Not to speak of the advantages which the ideal simplicity of these machines affords in the long run.

Under frequent conditions in practice it would be entirely impossible for any system to compete this ideally simple one; but I must say that again under different conditions a better solution is possible. This is the third form of my motor. This form

has never been criticized by the adversaries of my system and for a good reason, because it is the most efficient form of electric machine that has been produced to this day. I have shown that on such machines under favorable conditions an efficiency of 97% can be obtained. In output per weight it can be equaled

(Fourth handwritten page)

by no machine whatever, direct or alternating. It also possesses the ideal feature of running in absolute synchronism with the generator, while it has a good starting *figure*. This is the type of machine you have seen and which the W. Co *(assume Westinghouse Company)* propose to use for large units. You need not think that this form of machine has not been thoroughly tried. This machine merely is equivalent to two or three synchronizing machines coupled. A saving of expense and numerous practical advantages of *vital importance* is the result. For large units, especially, it would be utterly impossible for any system to compete with this. The advantages of *this* system are so great that even had we today a perfect alternating current motor requiring two wires, the system would have to be introduced just as soon as it comes to *earning* dividends *on* the capital. The three wire system offered to the direct current distribution *comprising* very small advantages, yet the three wire system was adopted. But what is recognized merely an advantage in direct current distribution will become dire necessity in the alternating system.

(The following written vertically in the left-hand margin of the fourth page)

Sincerely yours
N Tesla

Excuse haste

WHT/tmsxc

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Letter from Nikola Tesla to Edward Dean Adams dated March 12, 1893
Draft of text handwritten on Gerlach Family Hotel stationary (italics to show indistinct writing or clarification and bold to show text underlining)

(First handwritten page)

New York, March 12 **1893** (bold preprinted on Hotel stationary)

Dear Mr. Adams,

Although I have had exchange of thoughts with you in regard to your fav. (favor) of Feb. 23rd I consider it necessary to express myself quite clearly and by letter in regard to that subject.

The patent of Thomson Nr. 363,186, to which reference is made, has absolutely nothing to do with my discovery of the rotating magnetic field and the radically novel features of my system of transmission of power disclosed in my foundation patents of 1888. All the elements shown in the Thomson patent were well known and had been used long before by a number of

(Second handwritten page)

experimenters. I myself exhibited devices early in 1887, but I was not encouraged to work in that direction as I found that the motor was very inefficient and that the commutator and brushes caused trouble. I showed in my patents that alternating motors could be run without the employment of a commutator and I produced an efficient and practical motor, which I was able to run either on multiple or single alternating circuits. In fact, one of the many reasons why I advocated the adoption of two phase currents rather than three phase shown in my patents was, that a two phase motor was better *suitable* for single or ordinary *existing* circuits and that it could be operated on these circuits with fair efficiency, though smaller than that obtained by the use of multiple supply circuits. Some engineers do not realize this even today.

As to the *Bradley* patents,

(Third handwritten page – on Hotel letterhead stationary)

to which reference is likewise made, I would think it fair to all concerned that a thorough examination be made of their history and bearing. Such examination, which has been made by myself without the slightest prejudice, will convince you that in the earliest patent there is not the least *hint* of a method of transmission of power which would be novel, or of devices which would not have been described before. As regards the later patents they are plainly covered by my fundamental claims.

Engineers are beginning now to

(Fourth handwritten page)

notice that the *earning* capacity of an alternating plant with currents of **more than one** phase is much greater and that we are forcibly driven to introduce in our alternating systems of distribution multiple circuits. Some think that a perfect alternating motor, to be *on one* single circuit, could satisfy all needs. In reality such a motor would have a very limited value in a year or two, when, in consequence of competition the necessity will rise to use more than one circuit. The direct systems had to go through such a process merely for the sake of saving some copper, and their engineers had to make extensive changes and considerably complicate the systems at that.

Yours sincerely
N. Tesla.

P. S.
Thanks for the clippings received.

WHT/tmsxd



TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

Note from Nikola Tesla to Edward Dean Adams dated March 22, 1893
Draft of text handwritten on 5 x 8 inch lined notepaper (italics to show indistinct writing or clarification and bold to show text underlining)

(First handwritten sheet)

New York March 22, 1893.

Dear Mr. Adams,

Your fav. *(favor/letter)* received. I forward copy of "Electrician" of Aug. 5.

The writers of these articles are absolutely unacquainted (that is they were) with some facts. For instance they do not know that by merely winding the motor in a certain way absolute constancy of the field is obtained with two phases, so that it is the same as far as this is concerned

(Second handwritten sheet)

whether there are *two* or a million phases. But the gravest error the Authors make is that they express the belief that the constancy of field is important for the efficiency of the motor. In my earlier work I thought so and constructed motors with many phases. You will find in going over my writings and patents that I have before advanced all these views, and what these writers state in this journal is merely a repetition of what I have shown or stated. But I convinced myself that it is not im-

(Third handwritten sheet)

portant at all to have the field constant. The chief importance in an alternate current motor rests upon the *intimate* magnetic connection between the field and armature coils, as I have pointed out long ago. But even the closure of the magnetic circuit must be influenced by practical considerations. For instance some of my first motors I made with holes in the armature and field in order to close the magnetic circuit more completely. This *causes* some disadvantages when the machine is worked

(Fourth handwritten sheet)

directly, also when it is operated from a transformer (more or less). We found that for each motor, according to what it is built for, certain rules of construction had to be followed. On this entire books can be written. Even presently there are perhaps one half a dozen Engineers who know fairly well this subject.



I have to advise you to accept the two phase plan, though it would be much more for my personal interest if you would decide for the three phase. I shall explain this to you when I next have the pleasure of meeting you.

Yours sincerely

N Tesla.

Excuse in haste

WHT/tmsxf

TESLA MEMORIAL SOCIETY, INC.

BOOKS

Commentary by William Terbo, Executive Secretary

A great deal has been written by and about Nikola Tesla from the time he arrived in America in 1884, through his life and continuing to the present. The volume over time has depended on his level of fame at each period in his life or in the more recent recognition of the importance of his inventions and the intriguing aspects of his philosophy and personality.

At the height of his fame from 1890 to about 1910, the volume was staggering. *The Tesla Collection* (sponsored by the Tesla Memorial Society, Inc.) contains 4,500 pages of unduplicated material covering the period from 1885 to 1920. As Tesla was a darling of the popular press, the majority of items are from the ten New York daily and Sunday newspapers. But also included is a wealth of serious and technical items from scientific and professional publications. Nikola Tesla himself wrote at least 66 significant articles and lectures between 1887 and 1934 plus the series of articles in 1919 that made up his autobiography *My Inventions*.

In trying to sort out a relatively brief list of titles from my personal library of 100 or more "Tesla" books, I've tried to organize them into categories from the earliest to the most recent entries. For anyone wishing to write a biography, novel (or term paper) about Nikola Tesla need only the following four titles to provide the basic "Tesla" research. All have been published in many editions by many publishers in hard and soft cover, and in the case of collections, by many editors. I've just taken First Editions or best editions.

- *My Inventions*, The Autobiography of Nikola Tesla, Ben Johnson, Editor, 1982, Hart Brothers (111 pages). The series of six articles published between February and October 1919 in the magazine *Electrical Experimenter* with a new, informative and perceptive Introduction by Ben Johnson.
- *Prodigal Genius*, The Life of Nikola Tesla, John J. O'Neill, 1944, Ives Washburn (326 pages). A mixture of fact and fiction with many acknowledgements but without footnotes or bibliography to distinguish between the two. O'Neill, Science Editor of the New York Herald Tribune, was also a believer in spiritualism and psychic powers. He rushed the book into print and suggested, in a manner, that his friend, Tesla, also had such powers. This book, cited by many later writers, is primarily responsible for much of the mythology that surrounds Tesla's name today.
- *The Complete Patents of Nikola Tesla*, Jim Glenn, Editor, 1994, Barnes & Noble Books (535 pages). Almost more than you need to know with helpful Introductions by Jim Glenn.
- *Tesla, Man Out Of Time*, Margaret Cheney, 1981, Prentice-Hall (320 pages). A carefully researched work, both historically and technically, that caught the wave of new interest in Tesla, the man. More than 200,000 copies in print and

translated into a dozen languages including Japanese and Korean. (Ms. Cheney is a member of the Society Executive Board.)

To write a new biography of the whole life of Nikola Tesla, one that will supplant existing works such as Margaret Cheney's *Man Out Of Time*, will require a prodigious amount of research and dedication. The alternative is to address a situation in which Tesla played a pivotal role – to create a dramatic "hook" upon which the author can find a market for a new work that includes meeting the public thirst for more information about this enigmatic, reclusive giant whose scientific contributions are becoming more commonly known.

I have tried to make myself available to as many authors and playwrights as seek my assistance. By doing so, I hope to correct some of the errors that have been perpetuated by reliance on flawed research material. Currently, I'm dealing with at least half dozen writers who are moving forward on Tesla projects. Whether any new books or scripts from this effort will actually see the light of day is yet to be determined.

A number of new books have reached the market in the past year or two. Each relies on a "hook" to include a major and necessary sketch of Tesla, his personality and his participation in the subject at hand. While all include significant research on all aspects of the theme being examined, some have occasionally fallen back on the "easy" Tesla research described above. Among the most prominent are:

- *Empires of Light*, Edison, Tesla, Westinghouse, and the Race To Electrify The World, Jill Jonnes, 2003, Random House (416 pages). The "hook" is in the subtitle. Ms. Jonnes treats Tesla very kindly and with great sympathy, acknowledging every element of the Tesla AC system that won the day for Westinghouse. She also deals directly with Edison's obstructionism in defending his DC system. Westinghouse is very favorably characterized as the (unusual) model of a moral industrial tycoon. The book has been very favorably received and an option has been let to a prominent screenwriter for a commercial movie version. Capitalizing on the research for *Empires*, Ms. Jonnes is now writing a history of the Pennsylvania Railroad.
- *The Devil in the White City*, Erik Larson, 2003, Crown Publishers (447 pages). The "hook" is the creation of the 1893 Columbian Exposition "White City" from the swampy Jackson Park. Nearby, a serial killer built a "World's Fair Hotel" where scores of young women were tortured, killed and cremated. Mr. Larson examines the intrigue of Chicago politics surrounding the contracts for building the "White City" and the detective work (albeit too late) for catching the killer. The contest between General Electric and Westinghouse to light the Exposition is a part of the story – and Westinghouse's Tesla patent victory "helped change the history of electricity."
- *Nikola Tesla, The European Years*, D. (Dan) Mrkich, 2003, Commoner's Publishing, Ottawa (143 pages). Most Tesla writing deals with the romance of his American years of invention, success and frustration with only a superficial nod to his earlier years usually gleaned from his autobiography. Mr. Mrkich has

provided important new research that fills in details that Tesla omitted (or may have chosen to ignore) in later writings. He has visited every site (and every building, if still standing) and every source of records where Tesla lived, was educated and worked. In addition to sites in the former Yugoslavia, these locations include Graz, Prague, Budapest, Paris and Strasbourg. Among the new information revealed was Tesla's work in Maribor, Slovenia, where he worked as a common draftsman during the time he was avoiding University and his parents. I consulted with Mr. Mrkich and had the honor of writing the Foreword to *The European Years*. (Mr. Mrkich is a member of the Society Executive Board.)

- *Nikola Tesla, Tagebuch Aus Strassburg (Journal From Strasbourg)*, 2002, Nikola Tesla Museum, Belgrade (251 pages, German and Serbian). The Journal covers his correspondence with the Paris Edison Company (and an accounting of every Mark and Franc spent) for the year in Strasbourg (1883-84) while Tesla repaired the Edison lighting system, which had blown up in the presence of the Kaiser at its dedication. The Journal shows that Tesla could be an effective manager as well as a talented engineer. (The Society maintains a working relationship with the Tesla Museum.)
- *Executioner's Current*, Richard Moran, 2002, Alfred A. Knopf (271 pages). The story of how Thomas Edison's contribution to the American criminal justice system was born out of corporate greed. Edison's attempt to make George Westinghouse into America's Dr. Guillotine is a damning contradiction of the folksy image of this "Icon of Electricity." While Tesla's involvement in this contest is minor, his technology is paramount. Recently, I listened to a long NPR radio interview with Mr. Moran. When asked at the end of the interview what other thoughts he had about his book, Mr. Moran launched into a laudatory stream about his regard for Nikola Tesla. There is a contagion for writers when confronted with the personality of Tesla.
- *Harnessing the Wheelwork of Nature*, Thomas Valone, Editor, 2002, Adventures Unlimited Press (338 pages). A collection of articles (many not published before) dealing with Tesla's Science of Energy, with a lengthy Introduction to correlate the collection.

Three additional books must be mentioned their current timeliness and value.

- *The Man Who Invented the Twentieth Century*, Nikola Tesla, Forgotten Genius of Electricity, Robert Lomas, 1999, Headline Book Publishing, London (248 pages). The "hook" is the approach to Tesla's life and business decisions through the "money trail" and is ingenious and almost unique among the many other Tesla biographies. Dr. Lomas lectures in Engineering Management, is a lifelong enthusiast for Tesla and teaches his student how NOT to run their business affairs.
- *Tesla, Master of Lightning*, Margaret Cheney & Robert Uth, 1999, Barnes & Noble Books (184 pages). The Companion Book for the 90-minute PBS television biography *Master of Lightning* and the best publication available for a well-researched sketch of the complete Tesla. Illustrated with over 200 photos, illustrations and drawings, all with authoritative dates and sources.

- *Nikola Tesla, Guided Weapons & Computer Technology*, Leland I. Anderson, Editor, 1998, Twenty First Century Books (241 pages). Tesla's patented development of the first radio remote controlled device, a boat, demonstrated to the public in 1899. The patent included one of the fundamental building blocks of circuit and computer design, the computer AND gate. (Mr. Anderson is a member of the Society executive Board.)

These are a few additional books and publications that deserve to be mentioned for historical value or specific target audiences:

- *Nikola Tesla*, Memorandum book on the occasion of his 80th anniversary, 1936, Institute Nikola Tesla Foundation, Belgrade (520 pages). Birthday greetings from every corner of the world and Proceedings of a Conference on Tesla Technology accompanying the anniversary celebration. As an example, a portion of the congratulations from Ernest Rutherford of Cambridge reads "I was greatly impressed in my younger days by his experiments on high frequency currents. I have often made use of the Tesla transformer as a method of producing high voltages in my researches."
- *Lightning In His Hand*, The Life Story of Nikola Tesla, Inez Hunt and Wanetta W. Draper, 1964, Omni Publications (269 pages). A successful biography at the low point of Tesla's fame.
- *Light and other High Frequency Phenomena*, Nikola Tesla, 1893, National Electric Light Association (114 pages). An original copy of an historic Tesla lecture.
- *Priority in the Invention of Radio, Tesla vs. Marconi*, Leland Anderson, 1980, Antique Wireless Association (article, 9 pages). Chapter and verse citing Tesla priority through lectures, patents, experiments and the findings of the U.S. Supreme Court.
- *Nikola Tesla, Colorado Springs Notes 1899-1900*, Scientific Commentaries by Aleksandar Marincic, 1978, NOLIT / Nikola Tesla Museum, Belgrade (437 pages). Tesla's notes organized, interpreted and defined by Dr. Marincic, former Director of the Museum.
- *Nikola Tesla, Correspondence with Relatives*, 1993, Nikola Tesla Museum, Belgrade (397 pages). English version, translated by Nicholas Kosanovich, 1995, Tesla Memorial Society, Inc. (200 pages). This book is of particular interest to me as over one-third of the correspondence is between Nikola Tesla and my father, Nikola Trbojevich, also a prominent scientist and inventor.
- *The Streams of Lenard and Roentgen and Novel Apparatus for Their Production*, Nikola Tesla: Lecture before the New York Academy of Sciences – April 6, 1897, Leland I. Anderson, Editor, 1994, Twenty First Century Books (123 pages). A lecture that went far beyond the title with editorial discussion of departures by Mr. Anderson.
- *Nikola Tesla, A Spark of Genius*, Carol Dommermuth-Costa, 1994, Lerner Publications (144 pages). Latest and best of a number of Tesla biographies for younger students.

- *Tesla*, Tad Wise, 1994, Turner Publishing (381 pages). "A biographical novel of the world's greatest inventor."
- *Wizard*, The Life and Times of Nikola Tesla, Marc J. Seifer, 1996, Birch Lane Press (542 pages). In addition to a biographical narrative, Dr. Seifer, a noted handwriting expert, examines the stress of relationships between Tesla and many of his business contemporaries. I consulted with Dr. Seifer and had the honor to write the Foreword to *Wizard*.
- *Nikola Tesla On His Work With Alternating Currents and Their Application To Wireless Telegraphy, Telephony and Transmission of Power*, Leland I. Anderson, Editor, Sun Publishing (237 pages).
- *Inventors And Discoverers, Changing Our World*, National Geographic Society, 1988, National Geographic Book Service (320 pages). "Three Giants of Invention. Thomas Edison, Alexander Graham Bell and Nikola Tesla, with some of the inventions that changed our world".

There are many other lesser books, novels and plays that feature Nikola Tesla in one sense or another. I want to single out one last item: a play successfully produced in Manhattan to excellent reviews. The play was mounted with full cast, staging, theater and a firm price of admission. (Some costs of the production were offset by a grant from the Alfred P. Sloan Foundation.)

- *Tesla's Letters*, Jeffrey Stanley, 1999, Samuel French (72 pages). A play in 2 acts.

William H. Terbo Edited 6 January 2005 © 2003 WHT/tmsuf

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

PRINCIPLES OF THE TESLA MEMORIAL SOCIETY, INC. REGARDING COOPERATION, SPONSORSHIP AND ENDORSEMENT

First, it is important to emphasize the serious nature of the Society's mission as stated in our 1979 organizational document, repeated in our papers of incorporation in 1980 and summarized in the footer attached to much of our correspondence. The Society operates through voluntary contributions and donations and on honoraria given for appearances, interviews and technical support to various domestic and international media.

The Society cooperates with a very limited number of other organizations that promote a similar respectful appreciation of the man, Nikola Tesla, and his accomplishments. The Society has sponsored a limited number or projects that support important elements of our mission and that do not compromise our ethical standards. We have not "endorsed" any person or group promoting any product or theory, regardless of how meritorious they may seem. This saves us the difficulty of sorting or categorizing products and ideas as serious science, parascience or psuedoscience.

The Tesla Memorial Society, Inc., my position in the Society and quite often my direct relationship to Nikola Tesla appear on at least 50 websites. This generates a great number of letters and phone calls. Almost without exception they are a pleasure to receive and are an indication of the progress we've made in restoring Tesla's name to the prominence deserved. (I am often humbled by the degree of respect accorded to me through the accident of my closest blood relationship, grandnephew, to Nikola Tesla.)

The Society is usually unable to prevent any person or group from linking Tesla's name to whatever they are promoting. His name is an important part of history. We can only try to prevent the improper use of the Society's registered corporate name or my own personal name without authorization whenever we or I become aware of such use. (An example concerns the unauthorized use of a form of the Society's name: "Tesla Memorial Society of New York." This user is in no way connected with the Society and the Society is not responsible for any claim, promise or representation made by that entity.)

The Society always appreciates being made aware of any instances of the misuse of the Society's name or representations made in the Society's name.

William H. Terbo
Executive Secretary

2004/2005
WHT/tmsty

The Tesla Memorial Society, Inc. *is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla. The Society supports various cultural activities, participates in appropriate academic conferences and provides a source for an accurate representation of Nikola Tesla for the media. The Society is a non-political, non-profit, all volunteer membership organization founded in 1979, incorporated in 1980, operating under Section 501 (c) (3) of the U.S. Internal Revenue Code.*

Letter to Mrs. Alice Terbo, wife of Nicholas J. Terbo (Trbojevich) nephew of Nikola Tesla.

Hotel Pennsylvania, N.Y.

November 20, 1928

Mrs. A. Trbojevich
71 Glendale Ave
Highland Park, Mich.

My dear Mrs. Trbojevich,

Your husband - my nephew - is a man of genius and learning who is straining every fiber to carry out successfully some of his ideas which will bring him fame and fortune. Surely, you must be proud of him for what he has is worth far more than millions and a title.

Being near him you may perhaps not realize that he is in a dangerous state of overwork brought on gradually through years of concentrated effort. Under such conditions nothing will do him as much good as the unceasing care of a loving wife.

Possibly things are at present not just as you would like to have them, but your husband is sure to acquire great wealth and when his battle is won you will have everything to your heart's desire.

With kind regards and good wishes believe me.

Very sincerely yours,

N. Tesla

Hotel Pennsylvania N.Y.
November 20. 1928.

Mrs S. Trbojevich
71 Glendale Ave.
Highland Park, Mich.

My dear Mrs. Trbojevich,

Your husband – my nephew –
is a man of genius and learning
who is straining every fiber to
carry out successfully some of

Mrs. S. Trbojevich
71 Glendale Ave.
Highland Park,
Michigan.



his ideas which will bring him fame and fortune. Surely, you must be proud of him for what he has is worth far more than millions and a title.

Being near him you may perhaps not realise that he is in a dangerous state of over-work brought on gradually through years of concentrated effort. Under such conditions nothing will do him as much good as the unceasing care of a loving wife.

Possibly things are at present not just as you would like to have them, but your husband is sure to acquire great wealth and when his battle is won you will have everything to your heart's desire.

With kind regards and good wishes believe me

Very sincerely yours

N. Tesla.

without a thought of any compensation. It was not easy but I finally had it in perfect running condition. I was astonished when he gave me twenty dollars and wished that I had come to America years before. The next day I was thrilled to the marrow by meeting Edison who began ~~my American education right~~ then and there. I wanted to have my shoes shined, something I considered below my dignity. Edison said: "Tesla, you will shine the shoes yourself and like it. He impressed me tremendously. I shined my shoes and liked it.

I began the work for which I was engaged immediately and after nine months of strenuous effort I fulfilled my contract rigorously. The manager had promised me fifty thousand dollars but when I demanded payment, he merely laughed. "You are still a Parisian," remarked Edison, "when you become a full-fledged American you will appreciate an American joke." I felt deeply hurt as I had expected to use the money in the development of my alternating system and when some people proposed to form a company under my name, I accepted eagerly. Here was the opportunity I had vainly sought for years but my new friends were adamant in their resolve not to have anything to do with the worthless alternating currents which Edison condemned as deadly. They desired an arclight system and I had to comply with their request though the delay of my cherished plans was agonizing. In one year of day and night application, I managed to perfect the system which was adopted for lighting the city and some factories in the neighborhood. Then came the hardest blow I ever received. Through some local influences, I was forced out of the

NIKOLA TESLA NEW YORK

company losing not only all my interest but also my reputation as engineer and inventor. After that I lived through a year of terrible heartaches and bitter tears, my suffering being intensified by material want. Very often I was compelled to work as a laborer and my high education in various branches of science, mechanics and literature seemed to me like a mockery. Finally, I had the good fortune of meeting two capable and honest men who listened to me and came to my assistance. They organized a company, provided a laboratory and gave me a modest but sure financial support. I perfected my motors quickly having nothing else to do except to carry out plans I had formed years before. My inventions proved a success and attracted the attention of George Westinghouse. He was, in my opinion, the only man on this globe who could take my alternating system under the circumstances then existing and win the battle against prejudice and money power. He was a pioneer of imposing stature, one of the world's true noblemen of whom America may well be proud and to whom humanity owes an immense debt of gratitude.

I have to add that in all my troubles I did not neglect to declare my intention of becoming a citizen of this glorious country and in due course I secured my papers making me a proud and happy man.

Nikola Tesla

SCIENCE

Tesla at 75

(See front cover)

On Nikola Tesla's birthday in mid-July, the electrical term which his name has become is regenerated as a tall, meagre, eagle-headed man. Reporters hunt him out of his hotel cubicle for his yearly interview and for a day his long-standing fame flares again. People who all their lives have lived by means of the devices he has invented and inspired, people who have forgotten there were an Alessandro *Volta*, an André Marié *Ampère*, a Georg Simon *Ohm*, a Charles Augustin de *Coulomb*, a Luigi *Galvani* or a James *Watt*, are reminded that there still is a Nikola Tesla (pronounced *Teshlah*) who long ago gave them the Tesla induction motor which made alternating current practical, and the Tesla transformer which steps up oscillating currents to high potentials (15,000,000 volts he avers, with 100,000,000 possible).

Last week was Dr. Tesla's 75th birthday. Interviewers wished they might see him as he used to be seen in his Colorado laboratory a generation ago, strolling or sitting like a calm Mephistopheles amid blazing, thundering cascades of sparks 30 ft. long, Tesla currents alternating at such prodigious frequency that they would not harm a kitten. But instead they found him, not without some difficulty, in seclusion on the 20th floor of Manhattan's Hotel Governor Clinton. Pale but healthy, thin to ghostliness but strong and alert as ever, he received his callers in quiet. His hair is slate grey, overhanging eyebrows almost black. His eyes are blue. Only their sparkle and the shrillness of his voice indicate his psychic tension. He wore an ordinary U. S. business suit, a white collar-attached shirt and a commonplace tie.

To Nikola Tesla, all the world's a power house. For 40 years he has been reasoning, calculating and arguing that the earth has a definite electrical resonance. All that men need do to have unlimited power at their command, and that power without the necessity of transmission wires, would be to generate electricity in tune with the earth's. The generators might be at waterfalls, coal mines, anywhere. Only possible drawbacks would be the vast expense of installation and the fact that every power house on earth would be obliged to generate the same kind of current, and anyone could tap the current. There could be no financial control of electricity.

Nonetheless the late John Pierpont Morgan believed in the possibility of such wireless power. That was at the time when Mr. Morgan was creating U. S. Steel Corp. and International Mercantile Marine. He was not averse to world control of power and communications. (The House of Morgan is banker for American Telephone & Telegraph, International Telephone & Telegraph, Western Union, United Corp., and many another electrical utility.) Banker Morgan gave Genius Tesla great amounts of money for experiment. In Colorado in 1899, Tesla built a huge induction coil by which he generated and, he says, sent out wireless waves the same year Marconi established wireless communication between France and England. Tesla claims priority, because he conceived his system six years earlier, in 1893. The theoretical path of Tesla's waves were through the earth, not through the air as Hertzian waves go. On Long Island, Tesla built a steel tower 187 ft. high surmounted by a 68-ft. bossed dome. The tower was to disseminate wireless power. Mr. Morgan died in 1913. Dr. Tesla lacked money. He abandoned the tower, let it be destroyed in 1917.

Since then he has been pondering his theories. His annual interview has been a rehash of the same old subject—Broadcasted Power. But last week he made a "rare occasion" of his 75th birthday and talked about something new.

"I am working now upon two things," he said. "First, an explanation based upon pure mathematics of certain things which Professor Einstein has also attempted to explain. My conclusions in certain respects differ from and to that extent tend to disprove the Einstein Theory . . . My explanations of natural phenomena are not so involved as his. They are simpler, and when I am ready to make a full announcement it will be seen that I have proved my conclusions.

"Secondly, I am working to develop a new source of power. When I say a new *source*, I mean that I have turned for power to a source which no previous scientist has turned, to the best of my knowledge. The conception, the idea when it first burst upon me was a tremendous shock.

"It will throw light on many puzzling phenomena of the cosmos, and may prove also of great industrial value, particularly in creating a new and virtually unlimited market for steel.

"I can only say at this time it will come from an entirely new and unsuspected source, and will be for all practical purposes constant day and night, and at all times of the year. The apparatus for capturing the energy and transforming it will partake both of mechanical and electrical features, and will be of ideal simplicity.

"At first the cost may be found too high, but this obstacle eventually will be overcome. Moreover, the instalment will be, so to speak, indestructible, and will continue to function for any length of time without additional expenditures.

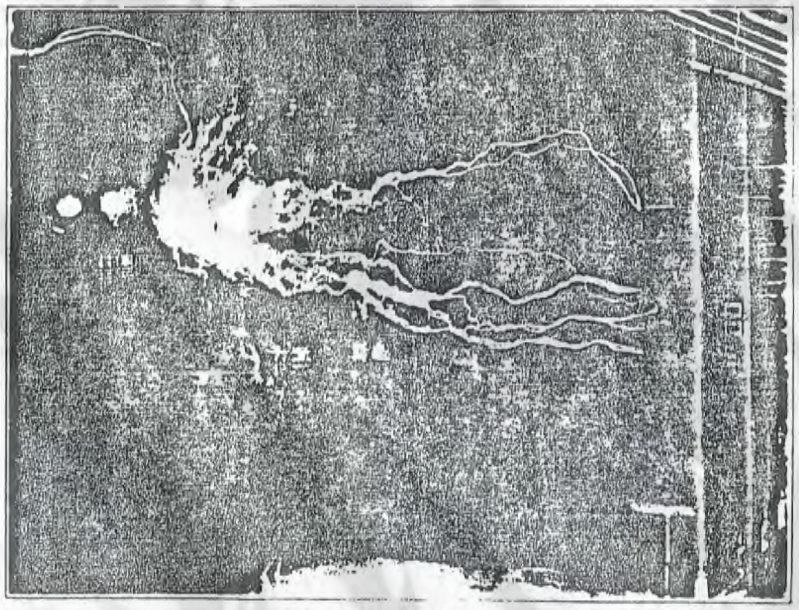
"Let me say that has nothing to do with releasing so-called atomic energy. There is no such energy in the sense usually meant. With my currents, using pressures as high as 15,000,000 volts, the highest ever used, I have split atoms—but no energy was released. I confess that before I made this experiment I was in some fear. I said to my assistants, 'I do not know what will happen. If the conclusions of certain scientists are right, the release of energy from the splitting of an atom may mean an explosion which would wreck our apparatus and perhaps kill someone. Is that understood?'

"My assistants urged me to perform the experiment and I did so. I shattered atoms again and again. But no appreciable energy was released."

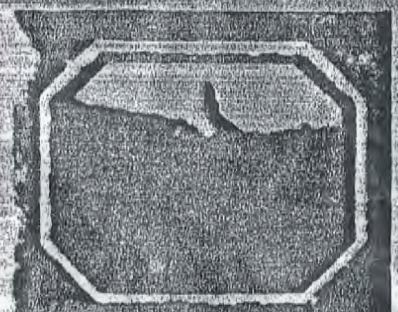
Badgered to reveal his own secret "source of energy," Genius Tesla politely evaded all questions, promised a definitive statement "in a few months, or a few years."

Yet he already has conceived "a means that will make it possible for man to transmit energy in large amounts, thousands of horsepower, from one planet to another, absolutely regardless of distance.

"I think that nothing can be more important than interplanetary communication. It will certainly come some day, and the certitude that there are other human beings in the universe, working, suffering, struggling, like ourselves, will produce a magic effect on mankind and will form



TESLA SPARKS & AUTHOR
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the foundation of a universal brotherhood that will last as long as humanity itself."

When?

"I have been leading a secluded life, one of continuous, concentrated thought and deep meditation. Naturally enough I have accumulated a great number of ideas. The question is whether my physical powers will be adequate to working them out and giving them to the world."

He received birthday greetings from Sir Oliver Lodge, Ernst Frederik Werner Alexanderson, Lee De Forest, John Hays Hammond Jr., Robert Andrews Millikan, Secretary of Commerce Robert Patterson Lamont, Henry Herman Westinghouse, and many another. Their greetings indicate the hope if not the confidence that "in a few months" or "a few years" the fame of Nikola Tesla's genius will weld one more astounding new device for mankind.

It is improbable that he will ever design such a device on paper, let alone in a machine shop, although before his mind's eye he may see it in every detail, motion, and detail. He is a great visualizer.

His first invention—before he was six and living at his native Smiljan, a Croatian village, in what is now Jugoslavia—was something the like of which he had never actually seen. He pictured it curved, pointed at one end, fastened to a string at the other. The child modeled a piece of iron according to his vision and thus had the hook which he needed to catch frogs. Similarly he completely visualized his induction motor, his coils and transformers, all his inventions, before he sketched and constructed them. He has unlimited confidence in his visual inventiveness. He no longer bothers to build, seldom bothers to make notes. He simply reclines and cerebrates.

Years ago he had a laboratory in Houston Street, Manhattan. It burned down. He lacked money and desire to rebuild. He had an apartment in midtown Manhattan, in West 40th Street opposite the Public Library whose engineering room he still occasionally haunts, and near the Engineers Club which he no longer will visit. In that apartment he kept a few terrifying but harmless lightning machines. The swank St. Regis Hotel whither he moved two years ago was no place for such devices. Dr. Tesla contented himself with studying four pet pigeons which nested in his rolltop desk. Maids complained. He moved.

Many such stories about him exist. Once, while walking along icy Fifth Avenue he slipped, threw himself through a flying somersault, landed on his feet, unperturbed kept on walking.

At the Hotel Governor Clinton where he now lives, if someone rings him up on the telephone or knocks at his door and he does not want to answer, he locks himself in the bathroom, turns the water loudly on. He is very sensitive to sensory stimuli. When he gets excited, blinding lights flash through his mind. He retreats to bed. A lifelong bachelor, habitually he goes to bed at 5:30 a. m., rises at 10:30 a. m. But he does not sleep the whole period. Proudly, yet almost plaintively, he explains: "I roll around and work on my problems."

Sen for Ju

Unbelievable news came last week from the Kyoto University Observatory at Kyoto, Japan—the discovery of a new planet 11,000 miles in diameter and only 180,000,000 miles from the earth! No planet so large and near (the earth's diameter is 7,918 mi., its distance from the sun 92,900,000 mi.) could exist beyond modern astronomers' knowledge. They long ago would have spied it with their telescopes, if not with their unaided eyes. Or they would have calculated its existence, as the late Percival Lowell calculated the existence of the unseen planet Pluto (TIME, June 2, 1930) from the perturbations it caused in the orbits of the known planets. Questioning cables went to Japan.

Kaname Nakamura of the Kyoto observatory staff, when his agitation subsided, was able to trace a gross error. A reporter had misread the Japanese picture-word which described the new heavenly body. The symbol for ten, or *ju*, is approximately that of the mathematical plus sign (+); for 1,000, or *sen*, approximately that of the plus-or-minus sign (±). The careless reporter had added the upper cross-bar. The new "planet" is a planetoid, about 110, not 11,000 miles in diameter. It lies between Mars and Jupiter in the general orbit of the thousand-odd other planetoids (TIME, March 24, 1930).

CINEMA

The New Pictures

A Woman of Experience (RKO-Pathé). Formula for spy stories: a shady lady enters government service in wartime and is assigned to make friends with an enemy spy. She also falls in love with an aristocratic naval officer. The crisis comes when she saves the life of the naval officer by outwitting the enemy spy. Few spy stories vary this formula greatly. *A Woman of Experience* varies it not at all. Spy stories are currently favored by producers as a measuring stick for actresses who seem capable of being built up into a resemblance to Greta Garbo (*Mysterious Lady*). Helen Twelvetrees is charming, low-voiced, auburn-haired, but she lacks the exotic numbness of Garbo. Marlene Dietrich *et al.* Her quiet and intelligent acting leaves the melodrama plausible but not exciting.

The Secret Call (Paramount) is mainly notable because its leading lady, Peggy Shannon, is being publicized as the successor to itty Clara Bow, whom she replaced in this picture when Actress Bow became "indisposed."

Stuart Walker, able technician of Indianapolis and Cincinnati stock companies, has handled the story well but shows his unfamiliarity with the cinema by not mov-

*His father, a Greek clergyman-orator; his mother, Georgina Mandic, a Serbian inventress of household thingamajies. "Her fingers were still nimble enough to tie three knots in an eyelash" when she was past 60. Dr. Tesla married in the U. S. in 1884 to work for Thomas Alva Edison, whom he soon quit. His naturalization papers he keeps in a safety box, his scientific medals and degrees in old trunks and cupboards.

QUOTES

A (By I. C. M. Brentano, 1931)

There are three aspects of Tesla's work which particularly deserve our admiration: The importance of the achievements in themselves, as judged by there practical bearing; the logical clearness and purity of thought, with which the arguments are pursued and new results obtained; the vision and the inspiration, I should almost say the courage, of seeing remote things far ahead and so opening up new avenues to mankind.

B (By Lee DeForest, inventor of the radio and telephone amplifiers, the triode, etc., in acknowledging his career inspiration, 1931)

For no one so exited my youthful imagination, stimulated my inventive ambition or served as an outstanding example of brilliant achievement in the field I was eager to enter, as did yourself. Not only for the physical achievement of your researches on high frequencies which laid the basic foundations of the great industry of radio transmission in which I have labored, but for the incessant inspiration of your early writings and your example, do I owe you a special debt of gratitude.

C (By Dr. B. A. Behrend, scientist, 1931)

To those of us who have lived through the anxious and fascinating period of alternating-current power transmission, there is not a scintilla of doubt that the name of Tesla is as great here as the name of Faraday is in the discovery of the phenomena underlying all electrical work.

D (By science editor and publisher Hugo Gernsback, 1931)

If you mean the man who really invented, in other words, originated and discovered - not merely improved what had already been invented by others - then without a shade of doubt Nikola Tesla is the world's greatest inventor, not only at present but in all history. His basic as well as revolutionary discoveries, for sheer audacity, have no equal in the annals of the intellectual world.



NIKOLA TESLA
The New York Times, 1934

cant, as were his researches and discoveries in radiations, material streams and emanations.

After his discovery of a system of transmission of power without wires and a high-potential magnifying transmitter, Tesla had been chiefly engaged—since 1902—in the development of a system of telegraphy and telephony, and designing a plant for the transmission of power without wires, to be erected at Niagara.

As early as 1908 Tesla made it known that he was experimenting with interplanetary communication. He firmly believed that most of the planets are inhabited and that messages could be sent between the earth and Mars, Jupiter and Venus.

He also had visions of harnessing the sun's rays and of utilizing the energy of the sea.

Son of Greek Clergyman

Nikola Tesla was born at Smiljan, Lika, a border country of Austria-Hungary, on July 10, 1856. His father was a Greek clergyman and orator, and his mother, Georgina Mandic, was an inventor.

His education began with one year in elementary school and then four years of the lower Realschule at Gospic, Lika. Then he went to a higher school at Carlstadt, Croatia, being graduated in 1873. He studied

2,000 ARE PRESENT AT TESLA FUNERAL

Cathedral of St. John the Divine Is Scene of Yugoslav State Function for Scientist

GREAT IN SCIENCE ATTEND

Ambassador Fotitch Heads the Procession of Mourners—Bishop Manning Assists

Inventors, Nobel Prize winners, leaders in the electrical arts, high officials of the Yugoslav Government and of New York, and men and women who attained distinction in many other fields paid tribute yesterday to Nikola Tesla, father of radio and of modern electrical generation and transmission systems, at an impressive funeral service in the Cathedral of St. John the Divine.

The service, conducted in Serbian by prominent priests of the Serbian Orthodox Church, was opened and closed by Bishop William T. Manning, assisted by Father Edward West, Sacrist of the Cathedral. The Serbian Orthodox Office for the Dead was said by the Very Rev. Dushan Shoukletovich, rector of the Serb Orthodox Church of St. Sava, who officiated in the name of the Serbian Orthodox Church in America.

City Is Represented

More than 2,000 persons attended the service. The city was represented by Newbold Morris, President of the City Council, who headed the list of honorary pallbearers. Other honorary pallbearers included Dr. Ernest F. W. Alexanderson of the General Electric Company, inventor of the Alexanderson alternator; Professor Edwin H. Armstrong of Columbia University, inventor of frequency modulation and many other im-

NIKOLA TESLA RITES TO BE HELD TUESDAY

Yugoslav Government-in-Exile Plans Official State Funeral

Nikola Tesla, father of radio and of the modern electrical transmission systems, who died Thursday night at the Hotel New Yorker at the age of 86, will receive an official state funeral under the auspices of the Yugoslav Government-in-Exile, it was announced last night by the Yugoslav Information Center.

The service will be held in the Cathedral of St. John the Divine on Tuesday at 4 P. M. Meanwhile, the body will lie in state at the Campbell Funeral Church, Madison Avenue and Eighty-first Street.

Yugoslavia, where Dr. Tesla was born of Serbian parents, will be officially represented by Ambassador Constantin Fotitch and many present and former high officials of that country. Among them will be Dr. Ivan Shubashich, Governor of Croatia; Dr. Bogoljub Jevtich, former Prime Minister of Yugoslavia; Branko Chubrilovich, Yugoslav Minister of Food Supply and Reconstruction; Franc Snoj, Minister of State representing the Slovenes, and Dr. Tesla's nephew, Sava Kosanovitch, president of the Eastern and Central European Planning Board, representing the Yugoslav, Czechoslovak, Polish and Greek Governments.

Dr. Tesla, who held more than 700 basic patents, is regarded as the man who laid the foundations for modern radio broadcasting and television; for the giant electrical transformers and other transmission apparatus, and for the basic apparatus that makes possible neon lights and fluorescent illumination.

To the end of his days Dr. Tesla claimed that the Marconi system of wireless telegraphy was an infringement on his method and apparatus for transmitting energy without wires. Dr. Tesla brought suit against Marconi in an effort to gain legal recognition of his claim. He blamed his failure to establish his patent rights to the paucity of technical knowledge at

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Nikola Tesla's Father: Milutin Tesla (1819 - 1879)

Milutin Tesla was born in Raduc, county Medak, Lika, on February 19 (OS), 1819. The Serbs came to Raduc from around Knin in the 1690s, having arrived there from western Serbia, via Hercegovina.

The name Tesla denotes either a trade, as *tesla* is Serbian for adze—a small axe with a blade at right angles to the handle—or a physical characteristic, such as protruding teeth, prevalent in the Tesla family. The name Tesla is also found in Ukraine. In Roman times, there was a place near Raduc, called *Tesleum*. Milutin's father, Nikola, was born in 1789, and during the Napoleonic wars, when Krajina was part of the newly-formed French Province of Illyricum, was a sergeant in the French army. He married Ana Kalinic, from the family of Colonel Kalinic, who is mentioned in the Raduc military records for 1735 and 1754; sometime after 1815, and the return of the old Austrian order, he moved to Gospic.

Nikola and Ana had two sons: Milutin and Josif, and three daughters: Stanka, Janja, and one whose name has not been remembered, but might have been Deva.

Milutin attended the German-language public school; then, together with his brother, went to the Military Officers' Training School; but the military profession, with its discipline and drills, did not suit him and, following a reprimand for not keeping his brass buttons bright enough, he left, and enrolled in the Orthodox Seminary in Plaski, completing his studies in 1845, as the foremost student in his class.



In 1847, Milutin married Djuka Mandic, from Gracac, and was ordained by Bishop Evgenije Jovanovic, who appointed him, first, to be in charge of the church in Stikad, and from there, on April 30, 1847, sent him to Senj on the Adriatic coast. The young pastor was expected to strengthen the congregation of some forty households, and represent Serbs before the "foreign and Catholic persons." Milutin was paid 200 forints per year, and an additional 40 forints toward a lodging, but these sums were barely enough to make ends meet.

Milutin was "a head taller" than his congregation, of pale, serious visage, high cheek bones, sparse beard, and a talented speaker and preacher. For his sermon "On Labour" he was awarded the Order of the Red Sash. He was a fine penman, and wrote many letters, some of which have been preserved.

On July 20, 1848, he writes to the local military commander, Major Froschmeier von Scheibenoch, requesting that he allow Serb soldiers to attend the Orthodox Church services on Sundays; his request was transmitted to the Governor of Croatia in Zagreb for a final decision, and the Commander continued to send all soldiers to the obligatory Roman Catholic mass—"holding our clergy as nothing," noted Milutin Tesla.

Poor material circumstances were compounded by ill health.

"It is impossible to preserve one's health here...", he writes to the Bishop. In mid-August 1850, he is so ill, that his brother-in-law, Toma Mandic, comes to Senj, to perform his pastoral duties, and stays for many months in the "stony church perched on a steep cliff."

On Easter Monday 1852, Milutin responds on the back of the received letter, and adds a post script, "Forgive me, I have no paper." On July 31, of the same year, he writes, "Justice sits on the throne, and law courts are, God forbid, as if we were under the Ottoman Porte..." But, "By God! Nothing is as sacred to me as my church and my forefathers' law and custom, and nothing so precious as liberty, well-being and advancement of my people and my brothers, and for these two, the church and the people, wherever I am, I'll be ready to lay down my life."

In mid-September 1852, after nearly five-and-a-half years in Senj, Milutin and Djuka put their three small children, and few possessions, in the ox-cart, for the 75 kilometre trek over the Dinaric mountains, back to Lika, to their new destination—the pastorage of St. Peter and Paul in Smiljan—the place of sweet basils.

The white church, at the foot of the Bogdanic mountain, beside the Vaganac running brook, was built in 1765, on the foundations of an older church. Beside the church, there was a fine wooden house for the family. Smiljan was a large parish and congregation, the priest's plot of land plentiful and fertile, the Tesla and Mandic extended families were close. Milutin's health improved, he subscribed to publications, and began to write articles for the *Serbian Diary* of Novi Sad, *Srbobran* in Zagreb, *Serbo-Dalmatian* magazine in Zadar, signing his name, variously, as "T", "M.T.", "Milutin Tesla, Pastor of the Orthodox Diocese of the Upper Karlovac", "Pastor in Smiljan", and most rarely, under pseudonyms, said to be Rodoljub Srbic and Rodoljub Pravicic.

In 1855, in the *Diary*, he writes, "Lika is, according to its territory and populace, large, and is made up of only Serbs, or if you like, of Serbs and Croats, of Orthodox and Catholic faith. In Lika, there are more Serbs of Orthodox than of Roman Catholic faith." But he also notes, "Except for the clergy and merchants or tradesmen, here and there, hardly anyone knows how to sign his name in Serbian."

He wanted to build a Serbian-language school in Gospic. In the *Dairy* of March 10, 1857, he writes, "Serbs in Croatia do not have High schools, teachers' colleges, or any other public places of learning. The sons of this poor people are not able to attend distant schools..." But all his efforts to improve the lot of the people were met by a wall of poverty, want of learning, and foreigners'[political agenda.

Milutin had a large library, consisting, not only of clerical books, but also of current *belles-lettres* in Serbian, Croat, German, Italian and French. He recited verses with ease, and liked to say, in good humour, that if such and such a classic were lost, he would recover it from memory! His most prized book was the 236-page *Sluzabnik*, printed in Venice in 1517, by Bozidar Vukovic from Podgorica, a book printer of great craftsmanship. After Milutin's death, Djuka kept the book; after her death, Nikola took it with him to New York, and had it restored; and after Nikola, the book passed into the hands of his nephew, Sava Kosanovic who, in 1950, as Yugoslavia's Ambassador to the United States, presented it to President Truman. This rare "Book of the Serbian Liturgy" is now on display in the Harry Truman Library in Independence, Missouri.

By 1859, there were five children in the Tesla family: Dane, born in 1848, Angelina in '50, Milka in '52, Nikola in '56, and Marica, born that year.

"Our priest has children above all children," the Smiljan Serbs said.

The first-born, Dane, in the words of his younger brother, was "gifted to an extraordinary degree."

The Tesla house was a busy place. There were endless visits by parishioners, relatives, passers-by, visiting both Milutin and Djuka, who was a spinner, seamstress and embroideress of renown; blind *guslars* stayed for days, singing heroic ballads. These were the happy years.

Milutin even indulged in some wit and yielded to small vanities. Nikola wrote the following:

"Amongst the help there was a cross-eyed man called Mane... he was chopping wood one day. As he swung the axe, my father cautioned him, 'For God's sake, Mane, do not strike at what you are looking, but at what you intend to hit..' On another occasion he was taking out for a drive a friend who carelessly permitted his costly fur coat to rub on the carriage wheel. My father reminded him of it, saying, 'Pull in your coat, you are ruining my tire.' He had the odd habit of talking to himself and would often carry on an animated conversation, and indulge in heated argument, changing the tone of his voice. A casual listener might have sworn that several people were in the room."

He once absent-mindedly asked his servant, "Whose cows are these?" only to be told, "Father Tesla's." Another time, Djuka was drying some newly-thrashed wheat, left it unattended, and a cow came and fed on it. She was upset at this waste of grain, but Milutin said, "Djuka, our cow ate our wheat."

For services Milutin had rendered some Moslems, a Bosnian Pasha sent him an Arab stallion. Milutin rode it when visiting more distant families. The horse was easily panicked. On one occasion, startled by wolves, the beast threw Milutin off, and galloped home, but was smart enough to retrace his steps and bring the rescue party to meet the abandoned rider. The 15-year old Dane was in charge of grooming the horse, and one summer day, in 1863, it cost him his life. This is how Nikola described it:

"This horse was responsible for my brother's injuries from which he died. I witnessed the tragic scene and altho fifty-six years have elapsed since, my visual impression of it has lost none of its force...."

Dane was buried in the graveyard, only steps away from the church and the house, and the life of the Tesla family would never be the same.

In the face of sudden-fallen hope, and to avoid looking at that fresh grave, the family moved to Gospic, where Milutin would be the pastor of the onion-domed Church of Great Martyr George for the next sixteen years. The seven-year old Nikola served as a bell ringer, mourning the loss of his brother, and of the green pastures and forests of Smiljan.

Milutin looked after his parish work, taught the Orthodox religion in the local schools, wrote less and less, and at a relatively young age, came to be called Old Man Milovan. He was on exceptionally good terms with the local Catholic priest, Kostrencic, and not infrequently, the two pastors would attend each other's liturgy. But watching his now only son, in his timorous awkwardness, guilelessness, extraordinary sensitivity, and ambitions which looked beyond the known and the familiar and did not bode well for a rational or happy life, there was no dance in Milutin's voice.

He wanted Nikola to follow a church calling, but Nikola was determined to be a professor, a technician, or an electrical engineer. And there was nothing Milutin could do.

Milutin Tesla would not live to see Nikola find his calling, did not live to see a single grandchild grow to adulthood—and there would be ten—children of his three daughters—amongst them an Archimandrite, an engineer, a medical doctor, a lawyer, an Ambassador. For in late March 1879, he fell ill from some unspecified malady, and died on April 17 (OS), aged 60 years.

The next day, Milutin was given a "funeral liturgy fit for a saint", and was buried in the Jasikovac cemetery in Divoselo. When the moment of burial came, the sun came out over the leafless cemetery, as it would burst forth during the funeral service for his son, many years later.

There are no surviving sermons of Milutin Tesla. His birth house in Raduc was burnt down in 1941. The Serbian villages in the "Medak pocket" were burnt down by Croats in 1993. The Church of St. George the Martyr in Gospic was demolished in 1992. The house and church in Smiljan, extensively renovated in the years after 1863, were burnt down in 1941; rebuilt in the 1980s; partially burnt down, and vandalized, in 1992; and now stand empty. 530 Smiljan Serbs were massacred in 1941; and the remainder, said to be eleven people, were ethnically cleansed in 1995. The little graveyard, where Dane was buried, is overgrown with weeds. The running brook dried up years ago.

The closest living descendent of Milutin Tesla is his great-grandson, William Terbo, who is American-born.

D. Mrkich, 2003

Nikola Tesla's Mother: Georgina-Djuka Tesla (1822–1892)

The mother's loss grips one's head more powerfully than any other sad experience in life.

—Nikola Tesla, in a letter to Jack Morgan, Nov.21, 1924

Nikola Tesla, the man who "invented the 20th century," has been declared, variously, as an Austrian, a Hungarian, an East European, Slav, Yugoslav, Croat, and a Serb — which he was by birth, heritage and his human consciousness.

Tesla's mother, Djuka, though always described accurately enough as an unlettered, but extraordinarily gifted woman, has been sometimes spoken of as a Croat. There was a tendency in the former Yugoslavia to look for unifying factors which would help bring its diffrerent nationalities closer together; thus, a certain political task fell on both the mother and son.

Djuka was born in Tomingaj ("Tomo's woodland" - so named after her great-grandfather), a daughter of Nikola Mandic (1800-63), a reknown Serbian Orthodox priest in Gracac, and a grandaughter of Toma Budisavljevic (1777-1840), a priest, who was also a military commander, a cartwright, and a fine bookbinder. She was the eldest of eight children. Her mother became blind when Djuka was 16, and she looked after her seven siblings, until her marriage to Milutin in 1847.



Djuka and Milutin Tesla had five children: Dane, Angelina, Milka, Nikola (1856-1943) and Marica. All three girls married Serbian Orthodox priests.

Nikola, the fourth child, was born on St. Vitus day, June 28 (OS), or July 10, according to the modern calendar, "at the stroke of midnight", during a summer storm. The village midwife, afraid of lightning, said, "He'll be a child of the storm", to which the mother responded, "No, of light."

Nikola was christened the very next day, by the priest from nearby Gospic, Toma Oklobzija; the godfather was Jovan Drenovac, a Captain in the Krajina army, also of Gospic. This baptism, within twenty-four hours of birth, with the priest coming to the house, instead of the child being taken to the church, is believed to have been due to the seeming poor health of the infant. Village lore also has it that the child's heart was beating on the right side of his chest.

There is no photographic likeness of Djuka.

Nikola Tesla wrote:

"My mother was indefatigable, and worked regularly from four o'clock in the morning till eleven in the evening. From four to breakfast time... I never closed my eyes, but watched my mother with intense pleasure as she attended... to her many self-imposed duties.... After breakfast, everybody followed my mother's inspiring example... and so achieved a measure of contentment."

He also wrote, "I must trace to my mother's influence whatever inventiveness I possess... My mother was especially gifted with a sense of intuition... an inventor of the first order and would, I believe, have achieved great things, had she not been so remote from modern life. The dexterity of her hands was such that she could tie three knots in an eyelash, when she was past sixty."

Djuka invented several labour-saving devices and home appliances. Her exquisite home-spun, embroidered travel bag, which Nikola kept all his life, may be seen in the Museum in Belgrade (see inset picture).

Smiljan was a busy parish, and the Tesla home a busy household. Village women, who still cooked over open hearths, and lit dimly their hovels with a flax string in tallow in a hollowed-out turnip, came to see what the priest's wife had in the way of needlework, tapestries, embroidered towels and feathered pillows, came to seek patterns and dyes and pieces of fabrics, came to seek food in hungry years: garbed in perpetual black from their thirties on, they sat, and sometimes whispered, re-arranging their kerchiefs, then wiping their faces with the hem of their long skirts. Rare was a family which had not lost men in wars, or children to disease.

Nikola's older brother, Dane, died in the summer of 1863, at the age of fifteen, following a fall off a horse.

Djuka woke up Nikola, and whispered, "Come and kiss Dane." Then she put him back to bed, and said, with tears streaming down her face, "God gave me one at midnight, and at midnight He took away the other one."

That year, the family moved from Smiljan to Gospic.

When he was in his early 20s, Nikola developed a passion for gambling, and at one point, in the summer of 1878, after he had lost everything at cards, Djuka gave him a roll of bills, and said, "Go and enjoy yourself. The sooner you lose all we possess, the better it will be. I know that you will get over it."

Milutin Tesla died in 1879.

Of Djuka's love for Milutin, the following anecdote has remained: some time after Milutin's death, a certain priest, Pepo Milojevic, who had wooed her, when they were both young, said, on meeting her, "Eh, Djuka, if you'd married me, you wouldn't now be a widow."

To which Djuka responded, "I would rather be Milutin Tesla's widow, than Pepo Milojevic's wife."

Djuka continued to live in the same apartment in Gospic, with her brother, priest Petar, who had succeeded his brother-in-law as the pastor of the Church of Great Martyr George. Nikola, who was to go to the United States in 1884, also helped support the family.

In February, 1892, Nikola was in Paris, giving a series of highly acclaimed lectures, when he received the following telegram from uncle Petar:

YOUR MOTHER ON DEATH BED. HURRY IF YOU WISH TO SEE HER ALIVE.

He cancelled further lectures, and rushed to Gospic.

"You've arrived Nidzho, my dear," Djuka said, when he came home, and the joy of seeing him worked the miracle of temporary recovery.

But not for long.

Night after night, Nikola sat by his mother's bedside, until he was in such a need of sleep, that on Good Friday, he was taken to a house two blocks away, to get some rest.

Nikola later wrote, "When I was alone in bed, I mediated on what would happen if my mother were to die. Would there be a disturbance in the ether?... I was sure that she would think of me to her last breath..... I struggled desperately against sleep and, with my senses sharpened by the darkness and stillness of the night, I watched intently.... Then nature prevailed, and I fell into a sleep or swoon. When I regained consciousness, an indescribably sweet song filled my ears and I saw a floating white cloud in the centre of which my mother was reclining, looking at me with loving eyes, her smiling face illuminated by a strange radiance unlike ordinary light, and grouped around her were figures like those of seraphims. Spellbound, I watched the apparation as it passed slowly across the room and disappeared from sight. In that instant, a feeling of absolute certitude swept over me that my mother had just died and, sure enough, a crying maid came running who brought this mournful message."

Djuka died on Easter Saturday, April 3, 1892, and was buried the next day, beside Milutin, in the Jasikovac cemetery in Divoselo. Six priests officiated at the burial. There was a large funeral procession, and a multitude of wreaths, including one each, from: children, brothers and sisters, grandchildren, nieces and nephews, and the citizens of Gospic.

From Gospic, on April 21, Nikola writes to his uncle Pavle, in Varazdin: "I am immeasurably sad, but console myself the best I can. I had long anticipated this sad event, but the blow, nevertheless, was heavy. I always hoped that mother would live longer, because she was strong, and mine and my uncles' successes were a strength to her...."

Nikola raised individual tombsones of white marble, and of the same height and likeness, to each of his parents. On Djuka's stone was written:

DJUKA TESLA
WIFE OF PRIEST TESLA

Whether Milutin's and Djuka's tombstones have been spared by recent wars is not known. Most clergy families in Lika were related by blood. All together, within the Mandic - Tesla families, between 1750 and 1941, there were 36 Serbian Othodox priests. The Second World War found six priests serving in the parishes in Lika. One died of natural causes, while the other five were killed by Croat fascists, together with 530 Serbs of Smiljan. By now, most of the churches in which the Mandic and Tesla priests served, have been burnt down, or lie in ruins. Djuka Tesla's birth house in Tomingaj, although "under the protection of the state" from 1945-91, was allowed to decay, and may or may not still be standing.

D. Mrkich, 2003


PRODIGAL GENIUS
NIKOLA TESLA

For

N. J. Tarbo

It is with great pleasure
that I inscribe to his
brilliant nephew this copy
of my biography of your
illustrious and dearly
beloved uncle.

Sincerely

John J. O'Neill

NEW YORK
"WORLD"
9 NOV. 1929

THE OCTOBER 21, 1929
EDITORIAL CITED
RANKED EDISON'S
INCANDESCENT LAMP
(AND EDISONS DC WORK)
AHEAD OF TESLA'S
INDUCTION MOTOR
(AND AC WORK)

MR. TESLA SPEAKS OUT

To the Editor of The World:

Permit me a few words of comment relative to The World editorial of Oct. 21 in which I am directly concerned.

Edison's work on the incandescent lamp and direct-current system of distribution was more like the performance of an extraordinarily energetic and horse-sensed pioneer than that of an inventor; it was prodigious in amount, but not creative. The lamp itself, consisting of a carbon filament in an exhausted globe, was well known and even patented years before. Crookes had employed incandescent conductors with leading-in platinum wires sealed in the glass and obtained extremely high vacua; the multiple-arc arrangement was frequently shown at institutions of learning, display windows and exhibitions with Geissler tubes; electric generators had been constructed, means for regulating current and voltage described, and canalization of electricity was as obvious as that of water, gas, compressed air or other commodity.

Irrespective of this, however, his primitive scheme of lighting was subject to fatal economic limitations and could have never proved a commercial success in competition. Indeed, during the past thirty-five years it has been almost wholly displaced by a more practical and efficient system based on my rotating magnetic field, a discovery which even hard-headed engineers and patent lawyers have declared to be "one of the greatest triumphs of the human mind." To convey an idea of the extent of its use I only need to quote Dr. B. A. Behrend, one of the foremost electrical experts, who in his book on the induction motor says: "Were we to eliminate from our industrial world the results of Mr. Tesla's work the wheels of industry would cease to turn, our electric trains and cars would stop, our towns would be dark, our mills dead and idle. So far-reaching is this work that it has become the warp and woof of industry."

Edison and his associates bitterly opposed the introduction of my system, raising a clamor against the "deadliness" of the alternating current, which proved very effective and led to the adoption of a commercial type of machine in the electrocution of criminals, an apparatus monstrously unsuitable, for the poor wretches are not despatched in a merciful manner but literally roasted alive. To the observer their sufferings seem to be of short duration; it must be borne in mind, though, that an individual under such conditions, while wholly bereft of the consciousness of the lapse of time, retains a keen sense of pain, and a minute of agony is equivalent to that through all eternity.

Had the Edison companies not finally adopted my invention they would have been wiped out of existence, and yet not the slightest acknowledgment of my labors has ever been made by any of them, a most remarkable instance of the proverbial unfairness and ingratitude of corporations. But the reason is not far to seek. One of their prominent men told me that they are spending $10,000,000 every year to keep Edison's name before the public, and he added that it is worth more to them

THAN THAT COST

Of course, in all that unceasing and deafening shouting from the housetops any voice raised to apprise people of the real state of things is like the chirp of a little sparrow in the roar of Niagara. So it comes that very few have a clear idea of the situation.

In truth, my system has not only provided energy for all purposes throughout the world but also revolutionized electric lighting and made it a great commercial success by reducing the cost of power and increasing enormously the distance of transmission. The greater part of the $60,000,000,000 which, according to President Hoover's statement, represented the value of electric business, can be traced to my system and its effect on the lighting and other industries. In view of this I feel that I also have done much to dispel darkness. Surely, my system is more important than the incandescent lamp, which is but one of the known electric illuminating devices and admittedly not the best. Although greatly improved through chemical and metallurgical advances and skill of artisans, it is still inefficient, and the glaring filament emits hurtful rays responsible for millions of bald heads and spoiled eyes. In my opinion, it will soon be superseded by the electrodeless vacuum tube which I brought out thirty-eight years ago, a lamp much more economical and yielding a light of indescribable beauty and softness. The technical resources of that time were inadequate to make it a practical success, but most of the difficulties will be overcome when cheap quartz glass becomes available.

No amount of praise is too much to bestow upon Edison for his vigorous pioneer work, but all he did was wrought in known and passing forms. What I contributed constitutes a new and lasting addition to human knowledge. Like his lamp, my induction motor may be discarded and forgotten in the continuous evolution of the arts but my rotating field with its marvelous phenomena and manifestations of force will live as long as science itself.

NIKOLA TESLA.

New York, Nov. 5.

The Mote and the Beam

To the Editor of The World:

The United States Senate by resolution condemned the conduct of Senator Bingham "as contrary to good morals and Senatorial ethics." But the venerable gentlemen fail to perceive that the Tariff Bill which the Senate has under consideration is also contrary to good morals and good ethics, because it is planned to take money out of the pockets of all the consumers to benefit a few of the producers by artificially increasing prices of food, clothing, materials, medicine, &c. Incidentally, the bill is bad for business, for when it is enacted into law it will further limit the limited purchasing power of the people, thereby curtailing production and bringing about unemployment.

By the way, what has become of the good, old-fashioned Democrats who used to write in the party platforms, "Protection is robbery"? Will the survivors please rise, or at least raise their voices.

JOHN J. EGAN.

New York, Nov. 6.

From WILLIAM TERBO 4/28/05

DEAR JEFF:

SOME ITEMS:

(1) I'VE WRITTEN TMSUZ TO ATTACH TO COPIES OF THE 1895 CENTURY ARTICLE. PLS REVIEW & CORRECT (IS YOUR WEBSITE OK?)

(2) I THOUGHT I HAD DUPED THE 1893 "LIGHT" BOOK & SENT YOU A COPY - BUT I COULDN'T FIND MY REPRO MASTER - AND NOW THINK I DIDN'T DO THE WHOLE BOOK. I'LL DO IT WITHIN A WEEK & SEND YOU A COPY.

(3) (SEE OVER)

Item #PP145 The Drawing Board, Dallas, Texas 75266-0420
© Wheeler Group Inc., 1976

(3) I ASKED YOU IF I HAD ALREADY SENT YOU A VIDEO (1) OF MY (INFORMAL) ARC SPEECH. IF YOU DON'T HAVE A COPY (AND WOULD LIKE ONE) I'LL SEND IT GRATIS. ABOUT (2). I EXPECT YOU HAVE A COPY. IF NOT, JUST ASK.

(4) MID AMERICA SCIENCE MUSEUM. FYI. I'VE WORKED WITH THEM SINCE BEFORE THEY OPENED. (THEY NOW REGRET THEY DIDN'T SEND ME A COPY OF THE BROCHURE TEXT TO EDIT.)

BEST REGARDS - MORE ITEMS WILL FOLLOW

William



Les Drysdale
32 Hoover Crs.
Hamilton, Ontario.
Canada L9A 3H1

Mr. William H. Turbo
21 Maddaket
Scotch Plains
NJ
07076 USA

Dear William
Thank you for the information you have provided me on Nicola Tesla and yourself. It was a valuable asset in coming up with an interesting monument. I did manage to speak to Ontario Power Generation and The Stratford festival theatre gave me access to their wardrobe warehouse in order to get the clothing accurate. I thought you might be interested in the fruits of my labor. I have sent you a copy of the photo I took of my concept drawing along with the outline I submitted. I hope you approve. The project is entirely funded and organized by The St. George Serbian Orthodox Church of Niagara Falls. Thank you again.

Sincerely,

Les Drysdale
Sculptor



The Nicola Tesla Memorial Project

The Sculpture I have designed is a realistic and historically accurate image of Nicola Tesla and a depiction of his most significant and recognizable invention, a polyphase AC motor.

My research which has included several books, among them ' Master of Lightning' and 'A man Out of Time' by Margaret Cheney, speaking with representatives of Siemens Westinghouse, Ontario Power Generation, The Niagara parks Commission, and correspondence with William H. Turbo of the Nicola Tesla Society, who is also Tesla's Great nephew. I've also been to consult with the Stratford festival costume department to ensure the accurate depiction of the clothing of the era. All of this has given me great insight and a firm grasp of his character and accomplishments, which will be reflected in the sculpture.

Description of Sculpture and Concept

EDITED AND IMPROVED

Tesla would be sculpted, as he would have appeared in 1896, age 39, about the time his inventions were being used to create The Niagara Falls Power station. His appearance would reflect the clothing of the time, in particular that which would be unique to Tesla himself.
I have chosen to depict Tesla, tall slender and elegantly attired, facing and walking towards the falls. He is pausing and in the process of creation. As the story goes, the idea for the AC motor was drawn on the ground during a walk with a friend. I have adapted this story by creating a natural pathway on which Tesla is walking. My intention is to show the 'mystery that is his mind', developing an abstract idea from the theoretical to the concrete, as most of his inventions were developed entirely from start to precise completion in his head. Tesla is drawing three sine waves that are out of sync by 120 degrees (his revolutionary idea that created AC electricity) The waves he is drawing flow out and into the real foundation beneath him, the AC motor, as does the idea become the foundation of every motor and generator to this day.

Sight And Placement

The sculpture has been designed specifically for the intended site. At 13ft 6in in total height and 12ft in length it will stand out both as an striking monument to an incredible man and also blend harmoniously with the landscape. The orientation is such that both pedestrians and automobile traffic will enjoy the full impact of the piece. The dynamic nature of the figure in motion with wind blown Prince Albert Jacket combined with the porous mass and intricate forms of the motor machinery, encourages and invites closer inspection which is the sculptures purpose, to celebrate, inform and educate the public about this amazing man and his accomplishments.
The outside housing of the motor has a large flat surface on which an informational inscription can be placed describing Tesla's involvement with power generation at the falls. On the backside I plan to inscribe the following quote, which is inspiration for the entire concept. "The possibilities of will power and self control appeal tremendously to my vivid imagination.... Until finally my will and wish become identical. They are so today, and in this lies the secret of whatever success I have achieved. My imaginings were equivalent to realities."

Tesla 1915

STATUE 1:1 (LIFE SIZE) $190K *
1:1.25 $360K

* 1:1 MUSEUM, NIAGARA PARKS COMM. WANTED 1:1 NOT TO OVERPOWER QUEEN VICTORIA IN THE PARK!







Niagara Falls – February 1, 2005

MAJOR ART COMPETITION
NIKOLA TESLA MEMORIAL SCULPTURE PROJECT

The St. George Serbian Orthodox Church in Niagara Falls, in partnership with The Niagara Parks Commission (NPC), undertakes a competition to create a significant monument to Nikola Tesla within the NPC's Queen Victoria Park. The proposed monument will be a sculpture of Nikola Tesla, positioned within Queen Victoria Park so as to have Tesla "looking at the falls". The project will be completely financed by the St. George Serbian Orthodox Church in Niagara Falls and its various Canadian and international partners. The proposed date for completion of the project is the 10th of July 2006, the 150th anniversary of Nikola Tesla's birthday.

Tesla was born at the strike of midnight on July 10, 1856 in Smiljan, Lika, which at the time was part of the Austro-Hungarian Empire. Inspired by a drawing of Niagara at the age of eleven, Tesla stated that he would come to Niagara Falls and harness its power and convert it to energy. In 1893, the Niagara Falls Power Company, financed by Morgan, Vanderbilt and Astor, approved a proposal for a power project at Niagara Falls which was completely based upon Tesla's polyphase alternating current technology for both generation at Niagara, and transmission and distribution to Buffalo. The first Niagara power station, designed by Tesla and using his technology, was a joint effort of the Niagara Falls Power Company, Westinghouse, General Electric and the Canadian Niagara Power Company and went into operation in August 1895. In short, Tesla is responsible for harnessing the enormous potential of both falls, eventually giving him clear title as the pioneer, discoverer and inventor of the principles and machines that created the modern electrical system.

This two-phased, juried competition is open to all. Phase I will require the submission of a current CV or résumé along with up to 10 images of work to date. These submissions must be made by March 15th, 2005.

Phase II will see up to 5 artists selected to submit detailed drawings and/or plans for the finished work. Artists so chosen will also be asked to submit a budget which includes cost of fabrication and delivery. A nominal fee of $500 Canadian will be paid for Phase II submissions. These submissions will be due by May 31st, 2005. We anticipate the awarding of the commission by June 15th, 2005.

Phase I submissions are due, postmarked no later than March 15th, 2005 and must be mailed to:

Nikola Tesla Memorial Project
P.O. Box 1579
Niagara-on-the-Lake, Ontario L0S 1J0
Canada

The full text of the Competition Brief can be emailed or posted to you.

For further information, contact the Project Selection Committee Chair:
Bill Auchterlonie
Phone 905 935-3514 or oniakara@sympatico.ca

31 MAY 2005	PROPOSAL SUBMISSION DEADLINE
15 JUNE 2005	SELECTION COMMITTEE AWARDING MEETING
25-6 JUNE 2005	PUBLIC ANNOUNCEMENT OF WINNER
1 FEB 2006	DELIVERY OF MONUMENT TO NIAGARA FALLS
MAY-JUNE 2006	SITE PREPARATION
LATE JUNE 2006	MONUMENT INSTALLATION
EARLY JULY 2006	MONUMENT UNVEILING

GUIDELINES

PHASE I

Phase I will require the submission of a current CV or résumé along with up to 10 images of work to date. These submissions must be made by March 15th, 2005.

All artists will be notified, by mail, of the results of the Phase One competition. Submissions by unsuccessful candidates will be mailed in the SASE provided by the artist.

The Selection Committee and/or Niagara Parks Commission reserve the right to refuse any and all submissions.

Please provide a SASE (Self-Addressed Stamped Envelope or Package) for submission return. It is the artist's responsibility to provide desired packaging for the return of phase one submission material.

Phase I submissions are due, postmarked no later than March 15th, 2005 and must be mailed to:

Nikola Tesla Memorial Project
P.O. Box 1579
Niagara-on-the-Lake, Ontario L0S 1J0
Canada

PHASE II

Phase II will see up to 5 artists selected to submit detailed drawings and/or plans for the finished work. Artists selected by the jury for Phase Two will be provided with a copy of an Agreement to Propose. Upon receipt by the Project of a signed copy of the agreement, each artist will be paid a fee. Artists so chosen will also be asked to submit a budget that includes cost of fabrication and delivery. A nominal fee of $500 Canadian will be paid for Phase II submissions. These submissions will be due by May 31st, 2005.

FINAL SELECTION

We anticipate the awarding of the commission by June 15th, 2005. The Selection Committee will make a recommendation to the Niagara Parks Commission Board of

NATIONAL ARTS CENTRE
CENTRE NATIONAL DES ARTS

MAIN STAGE SERIES

AFTER THE ORCHARD
September 15 to October 1

THE DONNELLYS: STICKS & STONES
November 10 to 26

I AM MY OWN WIFE January 12 to 28

CROWNS March 2 to 18

THE REAL THING May 11 to 27

STUDIO SERIES

THE DUMB WAITER and THE ZOO STORY
October 25 to November 5

EARSHOT February 14 to 25

BRILLIANT! The Blinding Enlightenment of Nikola Tesla March 21 to April 1

recovery April 18 to 29

FAMILY THEATRE SERIES

RAVEN STOLE THE SUN and CARIBOU SONG December 10 and 11

GEORGE AND MARTHA January 21 and 22

BENEATH THE BANYAN TREE April 8 and 9

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PORTRAIT OF AN UNIDENTIFIED MAN
July 12 to 23, 2005

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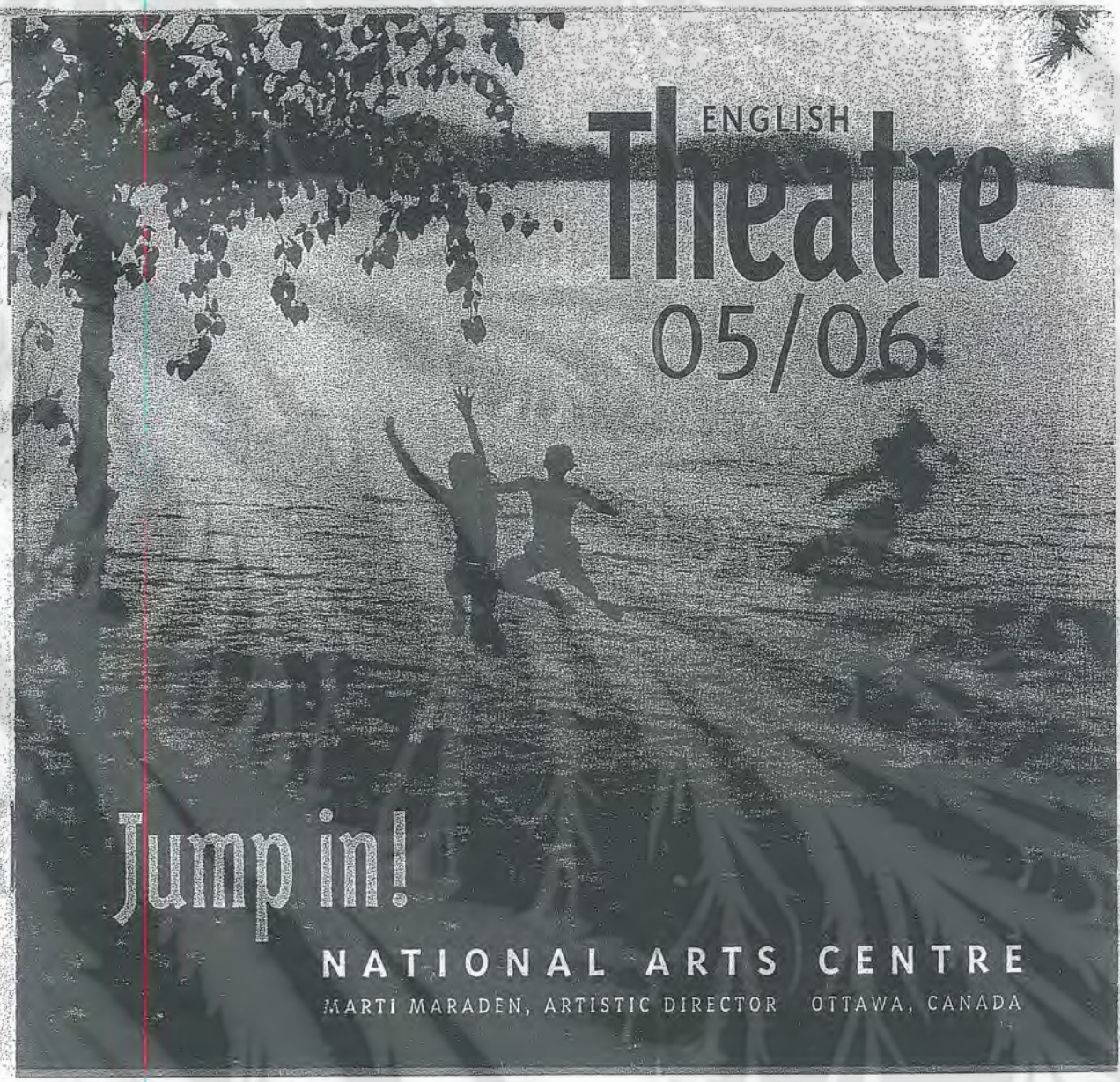
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Brilliant!

MARCH 21 to APRIL 1

The acclaimed touring production illuminates the Nation's Capital!

THE BLINDING ENLIGHTENMENT OF NIKOLA TESLA

written, directed and performed by Kim Collier, David Hudgins, Kevin Kerr and Jonathon Young

set design by Andreas Kahre
costume design by Mara Gottler
lighting design by Adrian Muir
video design by Amos Hertzman with Electric Company
sound design by David Hudgins with Electric Company

An Electric Company Theatre (Vancouver) production



PHOTO: A scene from *Brilliant!*, photo by Tim Matheson

In the nineteenth century, men like Nikola Tesla envisioned an electric new world, but sometimes reality couldn't live up to their dreams. A fascinating portrait of the inventor of the alternating current, breathtakingly staged in a visually stunning electrical storm of images, action and ideas.

"Visually stunning, quite literally dazzling its audience with brilliant thunderbolts"
The Scotsman

STUDIO SERIES

APRIL 18 to 29
WORLD PREMIERE

RECOVERY
by Greg MacArthur

directed by David Oiye

set and costume design by Kim Nielsen

lighting design by David Fraser

original music and sound design by Marc Desormeaux

with a cast of six including Kate Hurman, John Koensgen, Jeff Lawson and Alix Sideris

Around the world, people are succumbing to the addictive pleasures of a mysterious new substance. Society is threatened. But not to fear, *They* are taking care of everything...

An NAC English Theatre production

Commissioned by the NAC English Theatre



New work by
most excitin

"Paranoia
contagiou

Photo: Corbis Images

October 19, 2005

MEMO to Jeff Behary

Dear Jeff:

First, let me thank you for new material you've sent a couple of weeks ago, particularly the complete list of dad's patents. I've used it in detail in preparing a more comprehensive biography of Dad.

I'm enclosing a floppy of several items you may wish to use on your website along with hard copies of each document with suggested edits if you wish to use the item.

Two small corrections on the copies of items from your website that you enclosed with the patent list: Dad's anglicized first name is Nicholas (not Nikolas) and the name of our Society is Tesla Memorial Society, Inc. (the "Inc." should be included in the name the first time it is mentioned in any new item – it doesn't have to be included each time the Society name is repeated in the body of an item. The "Inc." is important to protect our registered name – as opposed to Vujovic's sham outfit, TMS of NY.)

These are the items I'm sending you of the floppy and/or as hard copy:

- Nikola Trbojevich biography (WHT/vy). It's written as a NY Times obituary and I've suggested some edits on the hard copy to convert it into a biography. The postscript at the end may be used elsewhere if you wish.
- Pupin 150th Anniversary (TMSsw2). You may use this as you wish and edit out the specifics relating to the TMS and myself.
- Terbo/Trbojevich Pupin connection (WHT/tmssu2). You may use this in any way you wish (or just keep it on file). Both Pupin items appear on the TMS website.
- Tesla DVD cover letter (TMSvx). I sent you the DVD in August but hadn't composed the cover letter at that time. We want the DVD to have as wide usage as possible without asking profit to the Society. Our web master Dave Sica is handling something about it on our website – but feel free to advertise it on your website – including steaming the entire thing. Just give credit as the letter indicates. (Streaming on our website may be too time consuming for our use.)
- Photo of Nikola Trbojevich (glossy). I'm not sure of the date but I make it to be about 1936 at 50 years of age. Please scan it and return the photo ASAP – I have only two or three of the first generation glossies!

• ADDED TMSVR2 (MARICICH OBIT) ~~[illegible]~~

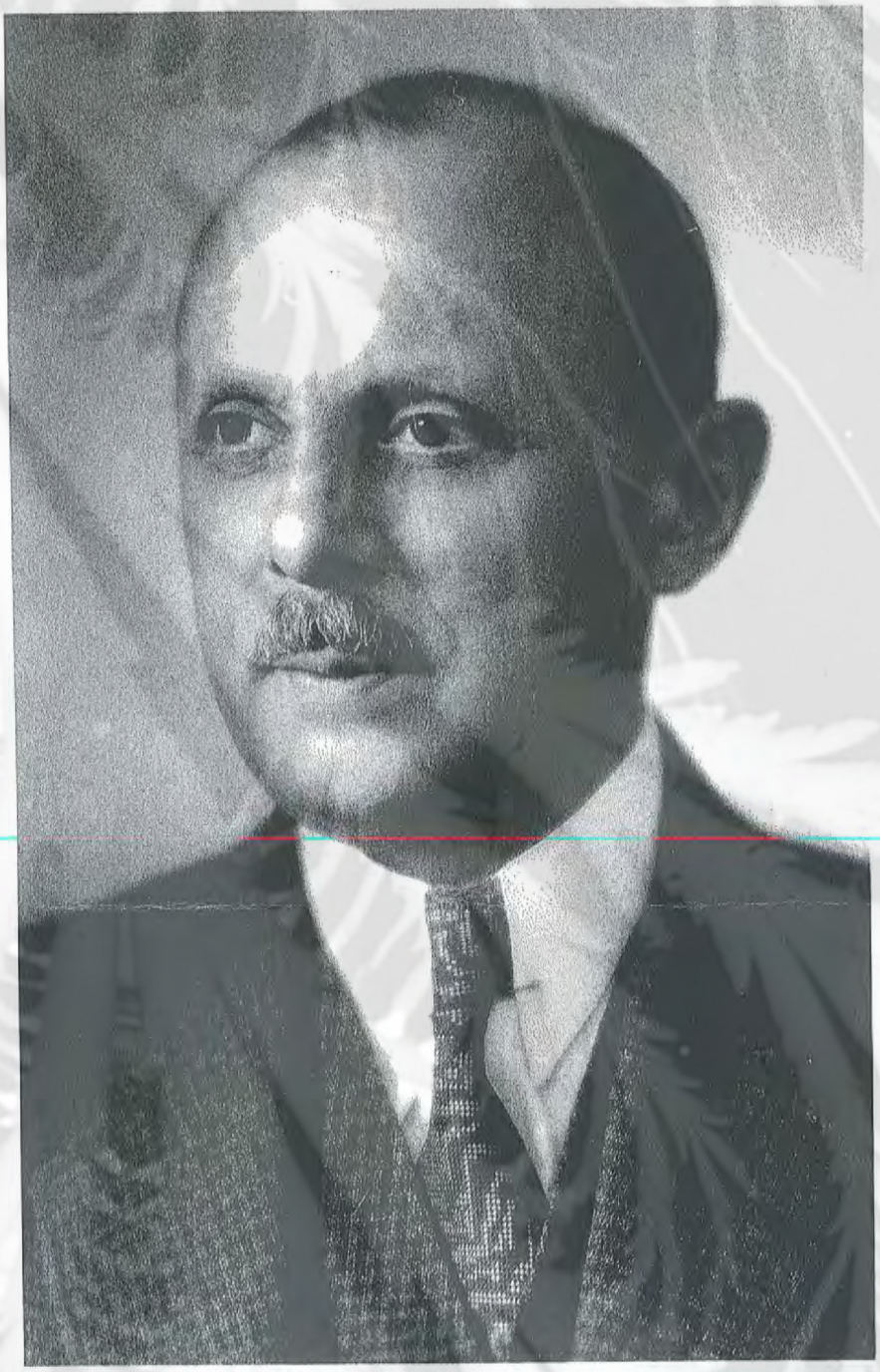
Let me know how you ultimately use these items. If you have any questions, just call.

Best Regards, Bill

TMSwb

JEFF: WHEN YOU SCAN DAD'S PHOTO – PLEASE SEND ME THE SCANNED VERSION ON A 3½ FLOPPY – ALONG WITH THE ORIGINAL. THANKS (CORRECTED VERSION IS OK – BUT SCANNED SHOULD BE A-1)

SEE NEWER DVD ENCLOSED



Tiffany Studios

JOFF. I'VE PUT THIS DOCUMENT ON THE FLOPPY. EDIT IT AS YOU SEE FIT AND PLEASE PUT SOMETHING ON YOUR WEBSITE.

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

DAN D. MRKICH, 1939-2005

It is with great sadness that the Tesla Memorial Society announces the passing on Wednesday, August 31, 2005, of Mr. Dan Mrkich, an active, honored and respected member of the Society Executive Board. While he was never a smoker, he succumbed to lung cancer first diagnosed on December 23, 2004. He fought and worked to the end.

Mr. Mrkich combined lifelong careers of diplomat and author. Born in the former Yugoslavia, he came to Canada at the age of 19. He worked as a steelworker and lumberjack before gaining his university degree. This was the background that served him so well as both trade negotiator and author.

Mr. Mrkich retired in 2004 from the Canadian Ministry of Foreign Affairs and International Trade. On February 25, 2003 he was awarded Her Majesty Queen Elizabeth II's Golden Jubilee Medal for having made "a significant contribution to Canada." Mr. Mrkich's responsibilities for international trade required extensive travel in pursuit of Canada's trade interests. This gave him a much broader access to the nuances of the many different nationalities and societies with which he came in contact.

Mr. Mrkich was the published author of nine books ranging from biographies and histories to popular fiction plus numerous articles and other contributions. He was a talented wordsmith and a tireless researcher. Book subject matter ranged from the biography of actor James Dean's boyhood to the romance of life in northern Canada.

Mr. Mrkich's interest in Nikola Tesla far exceeded the normal ethnic connection of people of similar Slavic backgrounds. As an eighth-grader he attended the same High School (Higher Real Gymnasium) attended by Tesla. And for one year he lived in the same little house where Tesla had lived 85 years earlier. His 2003 biography *Nikola Tesla, The European Years* addresses this early formative part of Tesla's life and professional career so regularly overlooked by the many other Tesla biographers.

The Tesla Memorial Society wishes to express its most sincere condolences to Dan's wife, Susan, his sons Alexander and Soren and his daughter Astrid. On a purely personal basis, I want to tell Susan and his grown children of the loss I feel. It is beyond that of a colleague but as a dear friend with whom I've worked so closely these several years.

William H. Terbo, Executive Secretary September 2, 2005 TMSvr2

The Tesla Memorial Society, Inc. *is the oldest U.S. based international organization in continuous operation honoring and perpetuating the memory and ideals of the great electrical scientist and inventor, Nikola Tesla. The Society supports various cultural activities, participates in appropriate academic conferences and provides a source for an accurate representation of Nikola Tesla for the media. The Society is a non-political, non-profit, all volunteer membership organization founded in 1979, incorporated in 1980, operating under Section 501 (c) (3) of the U.S. Internal Revenue Code.*

Visit our website: *teslamemorialsociety.org*



THIS TIKE STATUE (FULL SIZE LIFE SIZE) NOW BEING MADE FOR THE CANADIAN SIDE OF NIAGARA FALLS IN TIME FOR JULY 2006 (TESLA'S 150TH ANNIVERSARY. (MUST ABOUT $250K)



FYI

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

FAX COVER SHEET

Date: October 4, 2005

Pages: 3 **This cover** (tmsvw) plus **Dan Mrkich, 1939-2005** (tmsvr2) & **Principles Of The TMS Regarding …** (tmsty)

To: Senator George Voinovich, U.S. Senate, Ohio

Fax Number: (202) 228-1382 Phone Number: (202) 224-3353

Urgent For Review **Please Comment (2)** Please Reply **For Information Only (1)**

From: William H. Terbo

Fax Number: (732) 396-8852 (voice coordination preferred)

Phone Number: (732) 396-8852

Subject: (1) By your correspondence, I know you have been reading the serialization of Dan Mrkich's book *Nikola Tesla, The European Years* as published in the *American Srbobran*. I regret to inform you of the passing of my friend and colleague. (I had the honor of writing the foreword to *European Years*. If you would like a copy of the book as published, you need but ask.)

Message: (2) I'm sure that you will wish to speak of Nikola Tesla from the floor of the Senate at some time well before the 150th anniversary of his birth in July 2006. I would be happy to craft appropriate remarks for you to use. Just choose the facet(s) of his life or accomplishments on which you would like to focus and tell me how many minutes would be appropriate.

William H. Terbo
Executive Secretary TMSvw

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NIKOLA JOHN TRBOJEVICH (NICHOLAS J. TERBO) 1886-1973

Mathematician, inventor and perhaps the best-known gear expert of the modern age of the automobile, Nikola Trbojevich passed on December 2, 1973 at the age of 87 in Los Angeles. Mr. Trbojevich, also known socially as Nicholas J. Terbo, was the holder of 68 U.S. patents and a similar or greater number of foreign patents. The cause of death was septicemia and cardiovascular collapse. Surviving Mr. Trbojevich were his wife Alice Sinclair Hood (1891-1977) and his son William H. Terbo.

Mr. Trbojevich was a nephew of the great electrical genius Nikola Tesla "The Father of Alternating Current." He was the last survivor of a group of ten nephews and nieces borne by Tesla's three sisters. Both the Tesla and Trbojevich families were of clerical backgrounds, priests in the Serbian Orthodox Church. Tesla and Mr. Trbojevich were the only members of the extended family to pursue technological careers and the only ones to come to America.

Mr. Trbojevich's most notable work that brought him international recognition was the invention of the Hypoid gear. First published in 1923, it was a new type of spiral bevel gear employing previously unexploited mathematical techniques. The Hypoid gear is used on the great majority of all cars, trucks and military vehicles today. Together with his invention of the tools and machines necessary for its manufacture, the Hypoid gear became an integral part of the final drive mechanism of automobiles by 1931. Its effect was immediately apparent in that the overall height of rear-drive passenger automobiles was reduced by at least four inches.

Other inventions of Mr. Trbojevich are in the fields of steering gears, worm gears, universal joints, positive displacement liquid pumps, gauges, and gear cutting and grinding machines. Many of these inventions found important commercial and industrial use. His Gleason gear shaping machinery, invented and produced in the late 1920s is in use to this day. His reversible worm steering gear innovation was the first of its type to allow a car's steering mechanism to return to center after completing a turn maneuver. His inventions for angular and linear differential gauge block systems are in common use as measurement masters in factories throughout the world. His final patent (1967), for a nuclear reactor, was held in application form for many years because of its defense sensitivity.

Nikola Trbojevich was born on May 21, 1886, in the town of Petrovoselo in the Austrian county of Lika in the Austro-Hungarian province of Croatia (later Yugoslavia, now the Republic of Croatia.) His father was the Very Reverend (Prota) Jovo Trbojevich, at the time building a new Serbian Orthodox church in Petrovoselo, later to assume the post held by his father Very Reverend Danilo Trbojevich as Prota for the entire county of Lika based at the Trbojevich ancestral home at Medak. His mother was Angelina Tesla, eldest sister (by six years) of Nikola Tesla and daughter of the Very Reverend Milutin Tesla of Smiljan and later at Gospic, the county seat of Lika.

Nikola was the third of five children with two older brothers and two younger sisters. As was expected, the eldest son, Pero (church name Petronius), became a Serbian Orthodox priest rising to the highest rank, Arhimandrit (Archbishop), without offspring and breaking the family clerical connection with Lika. The other siblings also became professionals with careers away from the provincial county of Lika. The second son, Uros, became a lawyer and senator, representing Vojvodine nearer to Belgrade, older sister, Mica, became a medical doctor and director of the Woman's Hospital in Belgrade and younger sister, Marica, a teacher at the upper school level.

After completing his primary schooling in Lika, Mr. Trbojevich was sent to Budapest for eight years of Gymnasium (middle and high school) continuing to the Royal Technical University, graduating in 1911 with the degree of Diploma Engineer. By the time young Nikola had arrived in Budapest, Tesla was a world-known personality. Whether by design or natural ability there were strong parallels in the professional careers of Mr. Trbojevich and the uncle thirty years his senior.

After serving two years as an assistant to the Chief Engineer of the Royal Hungarian Post Office telephone department Mr. Trbojevich was offered a post as intern at the Western Electric Company in Chicago with postgraduate courses at Northwestern University. (His mother wrote very much as an older sister to her younger brother, Nikola Tesla, "Please be good and pay strict attention if you intend to do some good; help the boy in your firm. I know this would be the best school for him. He would be happy and at peace.") He arrived in March 1914, but the position at Western Electric lasted a very short time as the war in Europe began. His Austrian citizenship interfered with the national security aspect of the American telephone system and forced Mr. Trbojevich to change direction toward the mathematics of gear design.

Mr. Trbojevich joined the Illinois Tool Works as an engineer from 1915 through 1920 where he developed his specialty of gear design and received his first U.S. Patent (issued in 1920). As the principal consumer of gears is the automobile industry, he moved to Detroit in 1921 and became an independent inventor and consultant. The four patents that define the radical design of the Hypoid gear (U.S. 1,647,157) and the method of forming and cutting it (U.S. 1,465,149-1,465,151) were issued in 1923 and 1927. The reaction was exceptional. Several years were devoted to inventing the dozens of design details for the Gleason machinery necessary to cut the geometrical shapes of the gears. Nearly a dozen patents were issued to Mr. Trbojevich to secure the Gleason equipment.

In 1921 Mr. Trbojevich married Alice Hood of Evanston Illinois, the daughter of William Hood a commodities dealer, investor and member of the Chicago Board of Trade. Miss Hood had already established a business career in Chicago at the time. When they settled in Detroit they anglicized the difficult Trbojevich name to Terbo for social and her professional reasons. Of course, Mr. Trbojevich's name was already established in his profession and was never changed. He received his U.S. citizenship in Detroit on March 21, 1922. Their first son John (Jackie) was born in 1924 followed by William in 1930. Tragically, Jackie died in a fall in 1937. This was an unfortunate parallel to the Tesla family, who lost Nikola's older brother, Dane, in a fall at a similar age.

During the 1930s Mr. Trbojevich concentrated on improvements in automotive steering mechanisms, constant velocity universal joints and various implements to aid in their manufacture, areas intimately associated with American car and truck companies. Many of his improvements appeared on vehicles of several of the major marques. He was issued about two-dozen patents during the decade for novel equipment and concepts.

Mr. Trbojevich's success and wide reputation changed his relationship with Nikola Tesla from that of uncle and nephew exchanging information of family matters to that of colleagues. They wrote and visited regularly and commented and assisted on some of the complicated technical problems they each faced. (After Tesla's death in 1943, Mr. Trbojevich cooperated with his cousin, S.N. Kosanovich, another nephew of Tesla and after the war Yugoslavia's first ambassador to the United Nations, in directing Tesla's thousands of pieces of memorabilia to be placed in a new museum in Belgrade.)

Although Mr. Trbojevich worked with a number of major firms at that time, he retained his independent status until World War II became imminent. His familiarity with automotive drive systems and the specialized machinery necessary to manufacture them made his talents appropriate for the conversion to military vehicles.

After the war, he faced many of the problems other inventors face: his own earlier patents were cited against his new patents in his areas of expertise. This made a decision to become a professor at the Lawrence Institute of Technology in Detroit a more practical path. In 1960 Nicholas and Alice Trbojevich (Terbo) retired to Los Angeles where their son William was involved in the missile and space industry.

~~For more information contact:~~

William H. Terbo
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076
(732) 396-8852

Postscript: The lack of progeny in the direct line following Nikola Tesla and his three sisters is remarkable. The ten nephews and nieces mentioned above produced only six of the next generation, five of which are descended through the Trbojevich line. Of these six only William Terbo, son of Nikola, and Jovan Trboyevic, son of Uros, survive to this date. I have often commented that while most family trees are shaped like a Christmas tree, Tesla's family tree most resembles a telephone pole!

October 2005 WHT/vy

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

MICHAEL IDVORSKY PUPIN – 150TH ANNIVERSARY OF HIS BIRTH

The Tesla Memorial Society, Inc., its Executive Board and members join with all people who value the scientific and technological advances that have created the modern society in which we live in honoring the birth of Michael Pupin.

Michael Pupin, inventor, humanitarian and philosopher, is best known in the scientific community as the inventor of the Telephone Induction Coil (1899) a device that in one single step made long distance telephony possible. Sold in 1901 to the Bell System for an unprecedented sum that gave him the opportunity expand his vision beyond the field of his choosing. Also among Dr. Pupin's 34 U.S. patents were important radio developments and seminal work in Short Exposure X-Ray technology (1900) that led to the safe use of the new x-ray technology in medical diagnostics.

Michael Pupin was born on October 4, 1854 in the small village of Idvor in what is now a part of Serbia. He came to America at the age of 16 with only five cents in his pocket but with boundless energy. Within five years he had prepared himself for entry into Columbia College (University), graduated with honors, continued at Cambridge in England and received his Doctorate in Physics in Germany. He returned to a teaching position at Columbia where he soon founded the School of Electrical Engineering. Dr. Pupin remained associated with Columbia for the rest of his life. Shortly after his death on March 12, 1935 Columbia renamed the Physics building *Pupin Physics Laboratories*.

Dr. Pupin's Peace Conference advice to President Wilson was instrumental in resolving the borders that would define the new country that was to become Yugoslavia. Dr. Pupin served as the President of several important professional institutions including the New York Academy of Sciences, the American Institute of Electrical Engineers and the Radio Institute of America. Among his many honors was the Edison Medal (1920). Michael Pupin wrote three well-received books including the best selling autobiography of his fascinating life *From Immigrant To Inventor*, awarded the Pulitzer Prize in 1924.

On a personal note I wish to privately honor Michael Pupin on this significant year. Dr. Pupin was a personal friend and mentor of my father Nikola J. Trbojevich (Terbo) from the very time of father's arrival in America. It has been my privilege to honor Dr. Pupin several times in the past. I've attached a brief summary of that special connection.

William H. Terbo, Executive Secretary
(732) 396-8852

TMSsw2

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POINTS OF SPECIAL CONNECTION BETWEEN MICHAEL PUPIN AND WILLIAM TERBO THROUGH MY FATHER, NIKOLA TRBOJEVICH (TERBO)

On the occasion of the 150th anniversary of the birth of Michael Pupin it is appropriate to recall some details of a nearly lifelong appreciation of a person who was held in special esteem by ones father, a person not related by blood but by an ethnicity combined with professional accomplishment.

- In the Terbo (Trbojevich) household during my youth the name of Michael Pupin was as often mentioned as that of father's uncle, Nikola Tesla.
- When my father arrived in New York in 1914 it was Michael Pupin who first met him. Pupin had a very specific policy of meeting and assisting talented Serbs when they arrived in America through New York City. This began a relationship that lasted until Pupin's death in 1935. In spite of my grandmother, Angelina Trbojevic (Tesla's older sister), who very strongly instructing Tesla to "take care of my boy" Tesla was temporarily occupied at the moment of father's arrival.
- While my father always indicated that he already had a position as Design Engineer at the AT&T Western Electric Division in Chicago before his arrival in New York, I believe Pupin, who had a most influential connection with AT&T, offered additional sponsorship help.
- Father's rise to scientific prominence (over 150 patents including the seminal invention of the Hypoid Gear) gave great pleasure to both Tesla and Pupin and gave father a continuing social and professional access to both men.
- In 1979, to commemorate the 125th Anniversary of Pupin's birth, I made my first trip to Yugoslavia to attend the Anniversary Celebration in Idvor, Pupin's birthplace, and other Yugoslav locations. My invitation was as an Honored Guest of the Country (together with the Pupin Professor of Physics at Columbia University, Madame C. S. Wu, and Isidor I. Rabi, 1944 Nobelist in Physics and a famous product of the Columbia Physics program).
- On October 5, 1979, I delivered my paper *Pupin and Tesla – Parallels In Slavic Creativity* to the related International Symposium *Life And Work Of Michael Idvorsky Pupin* at Novi Sad, Yugoslavia. (My hospitality included tours of the entire former Yugoslavia including visits to Tesla's birthplace, Smiljan, Lika.)
- In 1993, to honor my father and his relationship with Michael Pupin, and with the sponsorship of the Tesla Memorial Society, Inc. (where I held the positions of Chairman of the Executive Board and Honorary Chairman), we made the 50-minute documentary video *From Immigrant To Inventor, Michael Pupin Remembered*. I wrote the script and provided the narration, Ljubo Vujovic was Producer and Iwona Vujovic was Technical Director. The Documentary had its premiere at Columbia University that winter.

William H. Terbo, Executive Secretary
Tesla Memorial Society, Inc.
21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076
(732) 396-8852

WHT/tmssu2

July, 2004

10/20/05

JEFF: I'M ENCLOSED A CORRECTED VERSION OF THIS DVD. DON'T USE THE OLD ONE I SENT IN AUGUST IF YOU INTEND TO STREAM PORTIONS (OR THE WHOLE THING) ON YOUR WEBSITE.

B.

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

NIKOLA TESLA, YOU'RE A MAN OUT OF TIME (DVD)

This high-energy DVD presents Nikola Tesla in a new and effective way. Crafted by brothers Paul and Stephen Kingsley Hone, media professionals in Los Angeles, it addresses an audience often overlooked by admirers of Nikola Tesla. The Hone brothers have been fascinated by the work and personality of Tesla for more than 15 years. They recognized that many or most of their friends and colleagues were aware of Tesla to varying degrees. What was troubling was the almost universal lack of knowledge by teenagers as to the specific connection between Tesla and those aspects of their lives they use every day. They didn't see the hand of Nikola Tesla in everyday items such as TV and MTV, their computers and the internet, radio and their tape decks, and more.

The result is a 6-minute DVD *Nikola Tesla, You're A Man Out Of Time* presented in the manner most familiar to and receptive by this particular audience without patronizing the more adult audience. The DVD simply tries to make the Tesla connection in the most entertaining way. Naturally, Tesla's fundamental contributions to the worldwide systems of alternating current electricity and radio are prominently identified. But the DVD also tells a bit of his personality: his wish to share his inventions and the obstacles he faced. It concludes with "you gave us today!" The result on the viewer is energy and pleasure.

Paul and Stephen Hone have graciously given the copyright ownership of this work to the Tesla Memorial Society, Inc. It is the objective of the Society to make the DVD available to the public in the widest way possible and without charge. Of course, the copyright details (which are mentioned in the opening and end credits of the DVD) must be retained whenever the DVD is played or retransmitted on any broadcast medium whether over the internet, TV or radio.

The composition of the DVD is a quickly shifting series of images with the high-energy song carrying the theme. The lyrics of the song are in relatively simple English. All of the lyrics are shown either as subtitles or in images on the screen. The universality of English should not make it necessary to add subtitles in a foreign language. However, it is permissible to add subtitles in a foreign language for use in other countries where it is determined that English would not convey the full intended impact of the song.

William H. Terbo
Executive Secretary

September, 2005

TMSvx

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TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076
April 6, 2007

Mr. Jeff Behary
627 36th Street
West Palm Beach, FL 33407

Dear Jeff & Rita:

First, I want to thank you for the continuing stream of interesting material you send. The Edison and Thomson letters are real finds. (I've spoken to Frank Jones briefly and will send him the video you mentioned along with some other material I think he will find interesting – as soon as I get a chance.)

About Waltham and speedometers. I've reviewed some of the correspondence between Tesla and Dad. (As you know, they had an extensive exchange of letters and telegrams covering each other's inventions, family and money, money & more money.) Besides complaining about money in a May 16, 1929 letter Tesla talks about Waltham in two ways: he borrowed $15,000 from a Philadelphia Bank based on his contract with Waltham that had to be repaid immediately because the bank was crippled by some Federal Reserve ruling; and, that Waltham wanted to buy his patent. (Tesla offered to reduce his royalty by 1/3 if Waltham paid $75,000. "That seemed a lot to them" and they predicted he would be without money!) There is more from Tesla on the subject.

On May 7, 1929 Dad concluded his letter with "As you had written (about) your speedometer, I think about Starret (Company) if you completed it. This is a big shame because you had a chance to get something." Jeff, I'll try to put something together as soon as I get a chance. (Time. It's the same old problem.)

Now I'll ask a favor of you. I've enclosed a note with six questions about Tesla's "Pancake" Coil. If you can give me some little (or a lot of) information that would answer the questions, I would appreciate it – both for the researcher and for myself.

I'll sign off for now. Thank you again for posting so much Society material on your website, particularly about Dad, his patents and Ether and Mass-Energy Theory. **If you post the six Coil questions, please edit out my email address.**

Best regards, Bill & Boyana

TMSbh

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Visit our website: *teslamemorialsociety.org*

TESLA MEMORIAL SOCIETY, INC
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076
March/April 2007

A private researcher has contacted me with questions about the electrical properties of Tesla's "Pancake" coil so prominently shown in one of the most famous Tesla photos.

To help this researcher (and for my own information) I am forwarding this list of six questions to only three of the most technically qualified friends/members of our Society. I'll send the questions in order, one person at a time – not to all three at once – to keep to the interruption for our colleagues to a minimum.

Whether or not you can provide any help with these questions, contact me by phone and/or fax (732-396-8852, voice coordination preferred for fax) or on my (more or less private) email (william.terbo@gmail.com). For fax, just mark up this page and send it back. If there is literature available that answers these questions, please cite name and location. Thanks in advance.

Questions on Nikola Tesla's "Pancake" Coil. What is/are its:

1. Inductive reactance?
2. Capacitive reactance?
3. Inductance?
4. Capacitance?
5. Shape of its magnetic field?
6. Are there any unusual properties of pancake design versus conventional coil design?

Remember, my engineering background is mechanical and rockets, so I will only absorb as much as I can and pass your answers to the requesting colleague.

Bill

TMSbg

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Visit our website: *teslamemorialsociety.org*



WITH PUPIN BUST

3/22/09



TESLA BUST (GIFT OF JOHN WAGNER AND HIS GROUP) AN EXCELENT RENDITION.



3/22/09

WITH PROF DR EDWARD G. COFFMAN & HIS WIFE

DEPARTME



WITH ARMSTRONG BUST AND (FAMOUS) SCULPTOR GREG WYATT

Tesla Memorial Society, Inc.

21 Maddaket, Southwyck Village
Scotch Plains, NJ 07076
(732) 396-8852

WILLIAM H. TERBO
Executive Secretary

Visit our website: teslamemorialsociety.org



TAPE AND ALL THE OTHER RECENT MATERIAL. VERY INTERESTING!

REGARDING THE UNLOCKED COPY OF TESLA 1893 "LIGHT ETC" BOOK. DAD'S MARGINALIA ARE VERY HARD TO READ. I'LL REVIEW THE ORIGINAL AND TELL YOU WHERE TO LOOK (LATER).

BEST REGARDS William

Item #PP145 The Drawing Board, Dallas, Texas 75266-0429
© Wheeler Group Inc., 1978

8/24/01

From WILLIAM TERBO

DEAR JEFF & RITA:

THANK YOU FOR YOUR CONFERENCE TAPE AND ALL THE OTHER RECENT MATERIAL. VERY INTERESTING!

REGARDING THE UNLOCKED COPY OF TESLA 1893 "LIGHT ETC" BOOK. DAD'S MARGINALIA ARE VERY HARD TO READ. I'LL REVIEW THE ORIGINAL AND TELL YOU WHERE TO LOOK (LATER).

BEST REGARDS William

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WILLIAM & BOYANA TERBO
21 Maddaket Southwyck Vlg
Scotch Plains, NJ 07076

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JEFF & RITA BEHARY
2809 NE 15TH STREET
POMPANO BEACH FL 33062

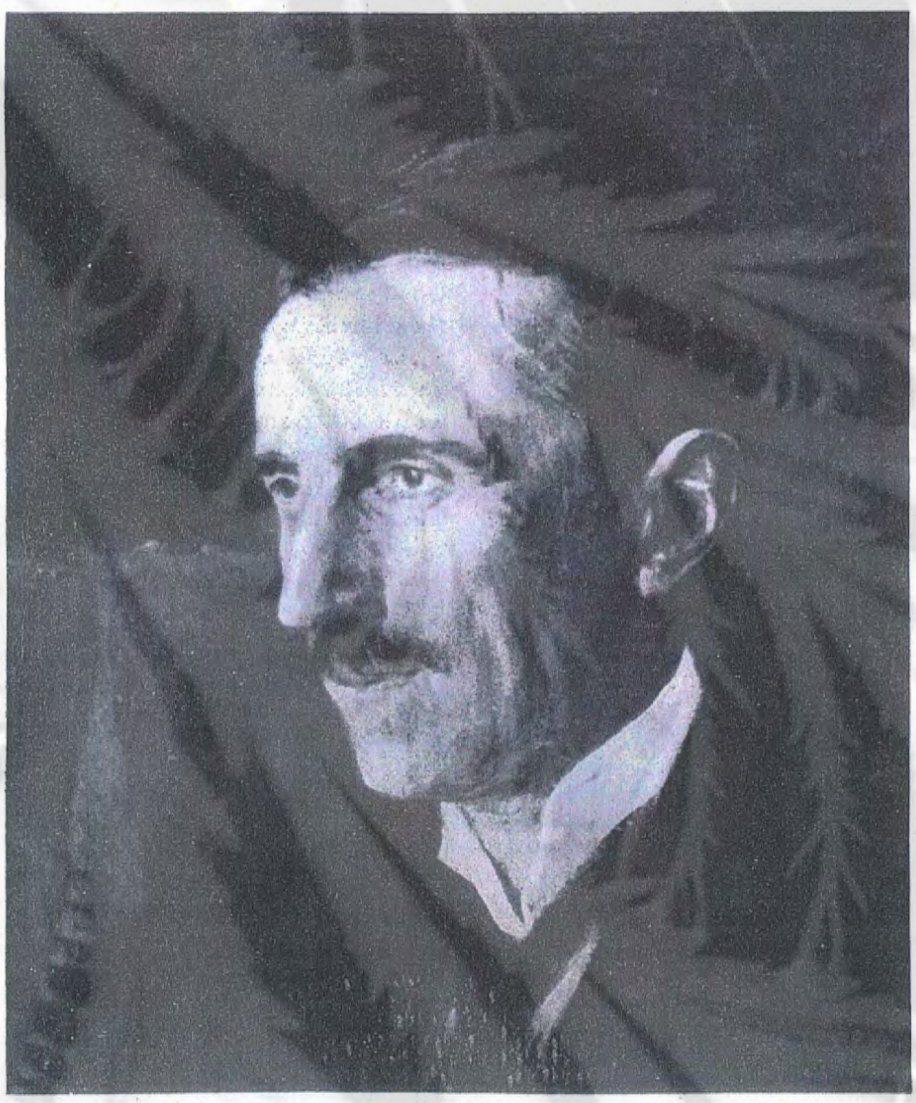
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FIFTEEN CENTS July 20, 1931

TIME

The Weekly Newsmagazine



Keystone

NIKOLA TESLA*

All the world's his power house.

(See SCIENCE)

*From a portrait by Princess Lwoff-Parlaghy.

Volume XVIII Number 3

Circulation Office, 350 East 22nd Street, Chicago. (Reg. U. S. Pat. Off.) Editorial and Advertising Offices, 205 East 42nd Street, New York.

4/6/09

From WILLIAM TERBO

JEFF & RITA.

3/22/09 COLUMBIA UNIV SCHOOL OF EE HOSTED UNVEILING OF BUSTS OF MICHAEL I. PUPIN AND EDWARD HOWARD ARMSTRONG. OF COURSE I ATTENDED, PUPIN IS VERY CLOSE TO ME (THROUGH MY FATHER.)

PUPIN'S BUST WAS GIVEN BY THE SERBIAN MONTENEGRO GOVERNMENT IN 2002 - AND JUST UNVEILED NOW !!!

PHOTOS OF EVENT.

Item #PP145 The Drawing Board, Dallas, Texas 75266-0429
© Wheeler Group Inc., 1976


НАРОДНА БАНКА ЈУГОСЛАВИЈЕ
ПЕТ НОВИХ ДИНАРА
5
ПЕТ НОВИХ ДИНАРА
5
ФАЛСИФИКОВАЊЕ СЕ КАЖЊАВА ПО ЗАКОНУ
АР 2995838


ПЕТ НОВИХ ДИНАРА
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БЕОГРАД 3. март 1994.
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Музеј Николе Тесле – Београд
5
ПЕТ НОВИХ ДИНАРА

TESLA MEMORIAL SOCIETY, INC.
21 Maddaket, Southwyck Village
Scotch Plains, New Jersey 07076

***Westinghouse* – Premiere of New Documentary on Life of George Westinghouse**

On Sunday, April 13, The Senator John Heinz Pittsburgh Regional History Center presented the Premiere of *Westinghouse* the feature-length documentary about the life, legacy and personality of George Westinghouse, his companies, his technology partnership with Nikola Tesla and his "Battle of the Currents" with Thomas Edison. The History Center is in association with the Smithsonian Institution.

Westinghouse is a 112-minute Inecom Entertainment Company Production, a part of the Inecom *The MINUTES OF HISTORY* Series. The feature was produced, written and directed by Mark Bussler and narrated by Carol Lee Espy, a Pittsburgh television personality. An audience of five hundred attended the Premiere program

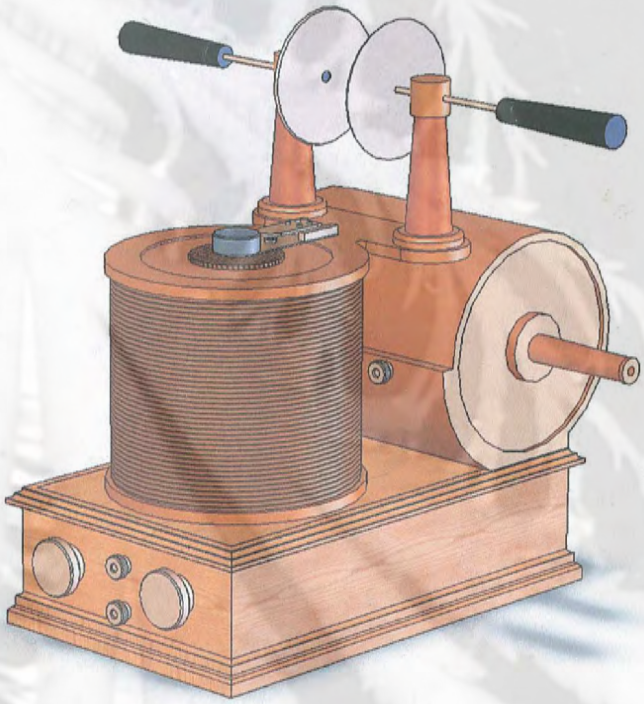
Heinz History Center President and Chief Executive Officer Mr. Andy Masich opened the program with welcome, short remarks and recognition of honored guests including George Westinghouse III and discussion panelists. Mr. Bussler was introduced and entertainingly described some details of the creation of *Westinghouse*.

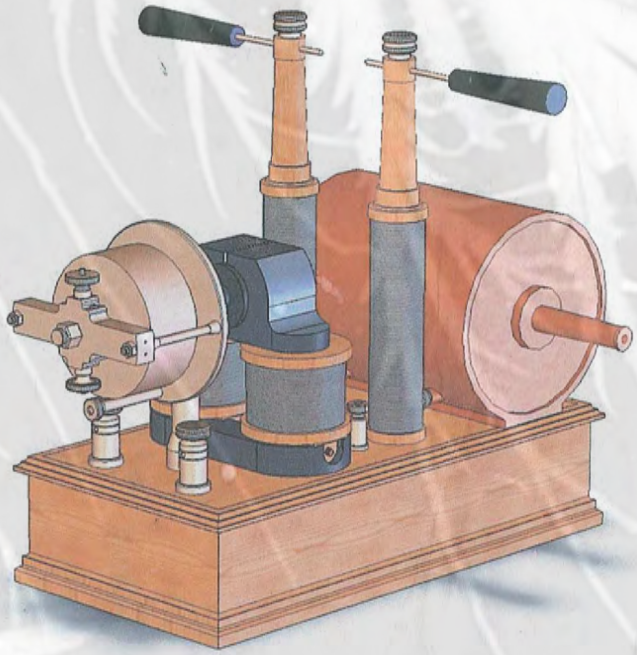
The Premiere program included a Panel Discussion hosted by Ms. Espy featuring panelists: Edward J. Reis, Executive Director of the George Westinghouse Museum from 1998 until it was integrated into the Heinz History Center in 2007; William H. Terbo, closest living relative of Nikola Tesla and Executive Secretary of the Tesla Memorial Society, Inc.; Quentin R, Skrabec, Jr. PhD, international management consultant and author of *George Westinghouse: Gentle Genius*; and David Cope, educator and historian of the 1893 Columbian Exposition in Chicago. The panelists, who are among those featured in *Westinghouse*, also answered many questions from the audience.

The Premiere program concluded with a showing of *Westinghouse*. Television presentation of the film will be announced in due course. At present the *Westinghouse* DVD can be purchased through commercial outlets such as Amazon.Com

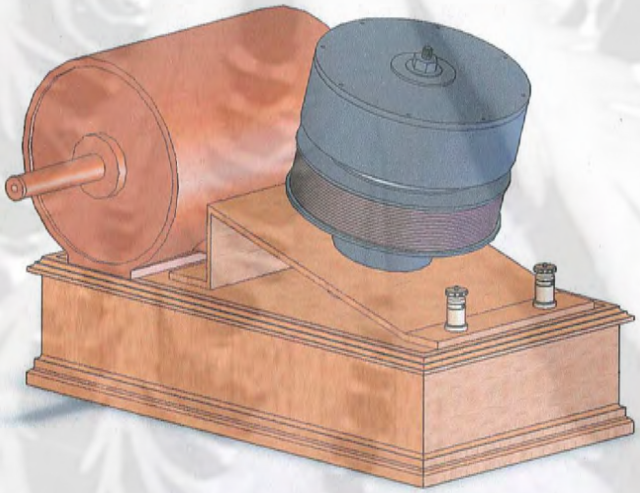
William H. Terbo April 2008

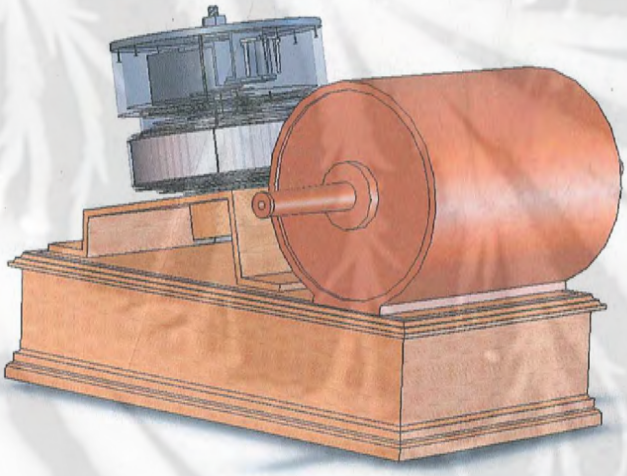
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Tesla Oscillators (C) Jeff Behary 2006

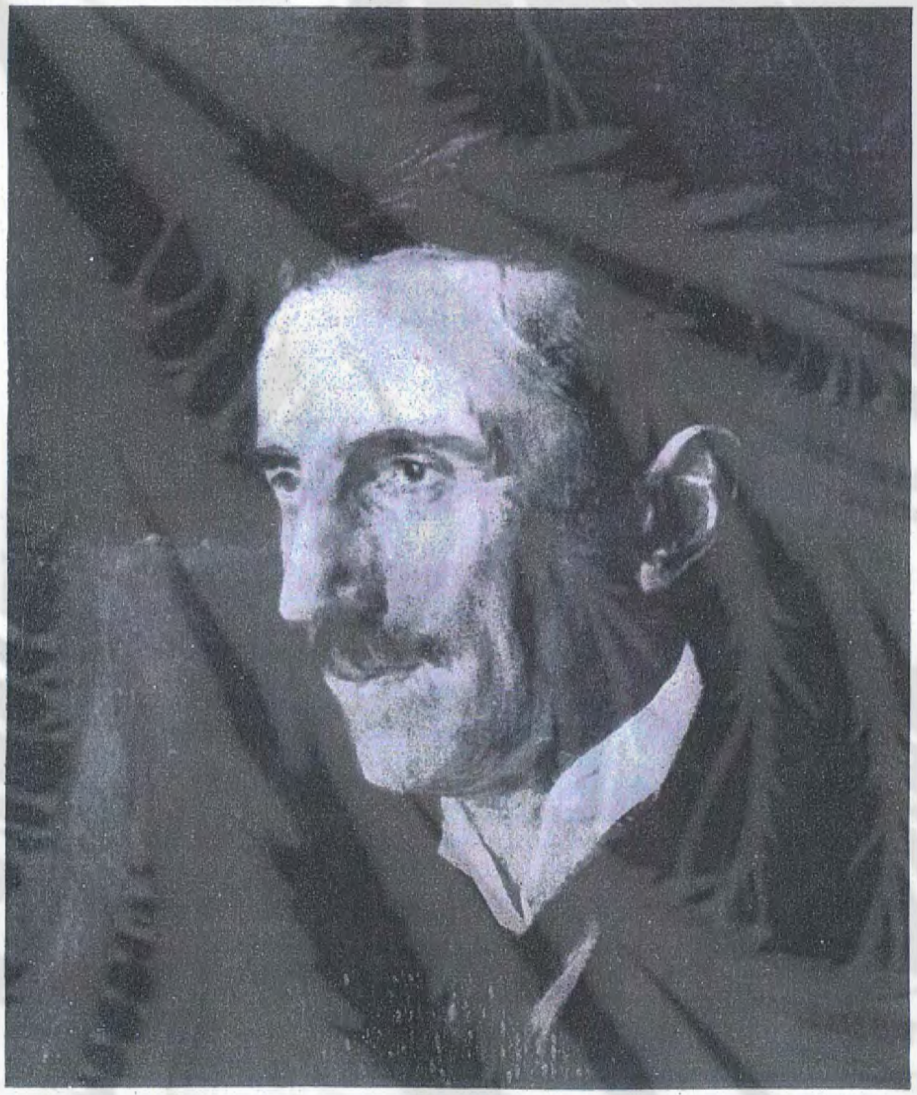




FIFTEEN CENTS July 20, 1931

TIME

The Weekly Newsmagazine



Keystone

NIKOLA TESLA*

All the world's his power house.

(See SCIENCE)

*From a portrait by Princess Lwoff-Parlaghy.

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SOCIETY & CLUB NOTES

Eighth Annual Meeting of the American Electro-Therapeutic Association.

The eighth annual meeting of the American Electro-Therapeutic Association will be held in Buffalo on the 13th, 14th and 15th of September. The business meetings of the association will be held in the rooms of the Buffalo Society of Natural Sciences, in the Public Library Building. Among the papers to be presented are some by the most noted writers on medical topics in this country and Europe, among which might be mentioned Drs. Apostoli and Gautier, of Paris, Dr. La Torre, of Rome; Dr. J. L. Parsons, of London; Mr. Nikola Tesla, of New York, and a number of others of equal prominence. The papers embrace the entire field of electro-therapeutics and will make the convention of great interest and value. A public exhibition of electrical apparatus for diagnostic, radiographic and therapeutic work will be held in the library, and a large number of entertainments have been provided for. Special hotel rates have been secured at Niagara Falls as well as in Buffalo for all attending the convention.

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SOCIETY & CLUB NOTES

Eighth Annual Meeting of the American Electro-Therapeutic Association, Buffalo, N. Y., September 13, 14 and 15, 1898.

SHORTLY after 10 a. m. Dr. Charles Rea Dickson, of Toronto, Canada, president of the American Electro-Therapeutic Association, called together the eighth annual meeting of the association in the rooms of the Buffalo Society of Natural Sciences.

President Dickson introduced Dr. Conrad Diehl, Mayor of Buffalo, who extended to the members of the association the freedom of the city. He spoke of the growth and development of electrical treatment since the time it was first adopted by the medical profession, as an important part of the professional apparatus. Dr. Diehl said that the street cars of Buffalo were now run by electric power from Niagara Falls, and urged the members of the association to inspect the electrical plant of the Buffalo Railway Company.

Dr. Francis B. Bishop, of Washington, responded to the Mayor's welcome on behalf of the American Electro-Therapeutic Association.

Reports of standing committees on scientific questions were next in order. Dr. Margaret A. Cleaves, of New York, presented her report on meters. The report was accepted and the committee requested to continue its labors. Dr. Cleaves announced that the committee was not willing to continue its work, but desired the appointment of a new committee on meters.

On constant current generators and controllers the report was asked for from the chairman of the committee, Dr. William J. Herdman, of Ann Arbor, Mich., but in his absence an auxiliary report was presented by another member of the committee, Dr. Robert Newman, of New York, who in 1896 was president of the American Electro-Therapeutic Association.

John J. Carty, electrical engineer, of New York, made a brief report of progress. He is chairman of the committee on electric light apparatus for diagnosis and therapy and the Roentgen X-ray.

Dr. Margaret A. Cleaves, of New York, read a paper on "Phlebitis, a Clinical Study," in which she gave a number of instances which had come under her professional supervision.

Dr. A. D. Rockwell read his paper on "The Diagnostic and Therapeutic Relations of Electricity to Diseases of the Central Nervous System."

AFTERNOON SESSION.

Shortly after 2 p. m. the second session of the American Electro-Therapeutic Association was called to order by President Dickson. The first paper on the programme was by an honorary fellow of the society, Dr. Georges Apostoli, of Paris. The subject was "New Uses of the Undulatory Current in Gynaecology." The paper was translated from French into English and was read by Dr. G. Betton Massey, of Philadelphia.

"Electricity in the Treatment of Uterine Fibromata" was the subject of a paper by Dr. Felice La Torre, of Rome, Italy, read by Dr. John Gerin, of Auburn, secretary of the association. Then came a paper on "Electro-Therapeutics in Gynaecology," by Drs. Georges Gautier and J. Larat, of Paris, France, read in English by Dr. Dickson, president of the association, followed by "The Treatment of Uterine Fibroids by Small Currents, Administered Percutaneously," by Dr. Richard J. Nunn, of Savannah, Ga.

Dr. W. H. White, of Boston, read a paper by Dr. Adelstan de Martigny, of Montreal, on "Treatment of Menorrhagia by Weak Current and Silver Internal Electrode."

This was the concluding paper on the afternoon programme. An early adjournment was taken in order that members of the association might avail themselves of the tally-ho ride about the city, planned by the committee on arrangements.

An invitation to the association to visit the storage battery of the Buffalo Railway Company was sent by Superintendent Danforth at the request of Mayor Diehl.

RECEPTION FOR THE VISITORS.

At 8:30 p. m. a public reception in honor of the members of the American Electro-Therapeutic Association was held in Alumni Hall, University of Buffalo Building, which was largely attended, many medical men of Buffalo being present.

Dr. Henry R. Hopkins, of Buffalo, a member of the local committee on arrangements, spoke of the earnest work of the medical men in this country. Dr. Charles Rea Dickson, of Toronto, president of the American Electro-Therapeutic Association, made a few remarks, in which he spoke of the fraternal feeling existing between the two great English-speaking nations at the present time.

Dr. Robert Newman, of New York, made a brief address, as did Dr. G. Sterling Ryerson, of Toronto, Deputy Surgeon General of the Canadian Militia.

SECOND DAY'S SESSION.

An executive session of the American Electro-Therapeutic Association was held at 9 a. m.

The report of the executive council on the revision of the constitution and by-laws was adopted, making some important changes in the governing rules of the association.

The first paper was presented by Dr. Lucien Howe, of Buffalo, who represented the Erie County Medical Society and also the New York State Medical Society at the convention. Dr. Howe's subject was "The Method for Using Cataphoresis in Certain Forms of Conjunctival Inflammation."

Dr. Howe illustrated his address by means of a number of his patients. His lecture was received with great interest and considerable discussion followed. Many questions were asked Dr. Howe concerning his methods of treatment.

Dr. Robert Newman, of New York, presented an able paper on "Electricity in Deafness and Stricture of the Eustachian Tube." In his address Dr. Newman rehearsed the history of a peculiar case which came under his professional care. He also cited a number of other cases, which had been reported by other physicians.

The discussion which followed Dr. Newman's paper was led by Dr. Howe, followed by Dr. A. D. Rockwell, of New York.

Dr. Grover W. Wende, of Buffalo, read a paper on "Electricity in Acne Vulgaris and Acne Rosaceae."

Dr. G. Betton Massey, of Philadelphia, led the discussion of Dr. Wende's paper, followed by Dr. Margaret A. Cleaves, of New York.

Dr. G. Sterling Ryerson, of Toronto, Deputy Surgeon General of the Canadian Militia and the accredited delegate of the Ontario Medical Association, was introduced by President Dickson, and spoke briefly, giving a number of instances of the effect of lightning-stroke causing diseases of the eye, in which the results were not permanently serious.

Dr. Francis B. Bishop, of Washington, presented a paper on "High Tension Current in Neuritis," which was followed by considerable discussion.

The final paper of the morning session was by Dr. Charles Rea Dickson on "Electricity in the Treatment of Goitre."

At 1 o'clock the convention adjourned until 2 p .m.

AFTERNOON SESSION.

President Dickson delivered his annual address, a part of which is as follows:

"The necessity for the existence of such an association as ours has been questioned not only here, but elsewhere, hence it may be necessary to explain our position. It has been asked 'Why should there be such an association?' Electricity is only one of many therapeutic agents, and it would be absurd to have a separate association to consider each therapeutic agent. At first

The Electrical Engineer.

Vol. XXVI. NOVEMBER 17, 1898. No. 550.

MISCELLANEOUS

High Frequency Oscillators for Electro-therapeutic and Other Purposes.[1]

BY NIKOLA TESLA.

SOME theoretical possibilities offered by currents of very high frequency and observations which I casually made while pursuing experiments with alternating currents, as well as the stimulating influence of the work of Hertz and of views boldly put forth by Oliver Lodge, determined me some time during 1889 to enter a systematic investigation of high frequency phenomena, and the results soon reached were such as to justify further efforts towards providing the laboratory with efficient means for carrying on the research in this particular field, which has proved itself so fruitful since. As a consequence alternators of special design were constructed and various arrangements for converting ordinary into high frequency currents perfected, both of which were duly described and are now —I assume—familiar.

One of the early observed and remarkable features of the high frequency currents, and one which was chiefly of interest to the physician, was their apparent harmlessness which made it possible to pass relatively great amounts of electrical energy through the body of a person without causing pain or serious discomfort. This peculiarity which, together with other mostly unlooked-for properties of these currents I had the honor to bring to the attention of scientific men first in an article in a technical journal in February, 1891, and in subsequent contributions to scientific societies, made it at once evident, that these currents would lend themselves particularly to electro-therapeutic uses.

With regard to the electrical actions in general, and by analogy, it was reasonable to infer that the physiological effects, however complex, might be resolved in three classes. First the statical, that is, such as are chiefly dependent on the magnitude of electrical potential; second, the dynamical, that is, those principally dependent on the quality of electrical movement or current's strength through the body, and third, effects of a distinct nature due to electrical waves or oscillations, that is, impulses in which the electrical energy is alternately passing in more or less rapid succession through the static and dynamic forms.

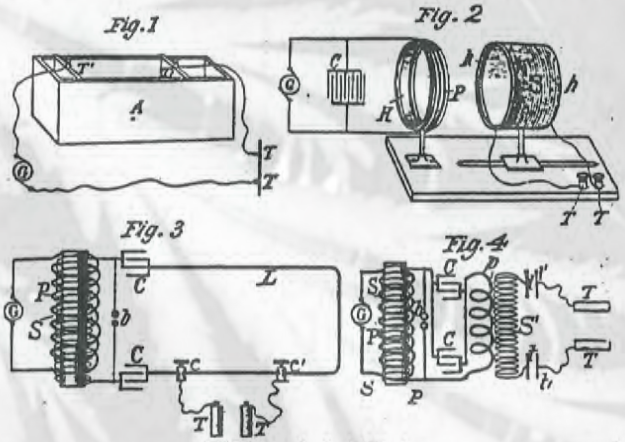
Most generally in practice these different actions are co-existent, but by a suitable selection of apparatus and observance of conditions the experimenter may make one or other of these effects predominate. Thus he may pass through the body, or any part of the same, currents of comparatively large volume under a small electrical pressure, or he may subject the body to a high electrical pressure while the current is negligibly small, or he may put the patient under the influence of electrical waves transmitted, if desired, at considerable distance through space.

While it remained for the physician to investigate the specific actions on the organism and indicate proper methods of treatment, the various ways of applying these currents to the body of a patient suggested themselves readily to the electrician.

As one cannot be too clear in describing a subject, a diagrammatic illustration of the several modes of connecting the circuits which I will enumerate, though obvious for the majority, is deemed of advantage.

The first and simplest method of applying the currents was to connect the body of the patient to two points of the generator, be it a dynamo or induction coil. Fig. 1 is intended to illustrate this case. The alternator G may be one giving from five to ten thousand complete vibrations per second, this number being still within the limit of practicability. The electromotive force—as measured by a hot wire instrument—may be from fifty to one hundred volts. To enable strong currents to be passed through the tissues, the terminals T T, which serve to establish contact with the patient's body should, of course, be of large area, and covered with cloth saturated with a solution of electrolyte harmless to the skin, or else the contacts are made by immersion. The regulation of the currents is best effected by means of an insulating trough A provided with two metal terminals T' T' of considerable surface, one of which, at least, should be movable. The trough is filled with water, and an electrolytic solution is added to the same, until a degree of conductivity is obtained suitable for the experiments.

When it is desired to use small currents of high tension, a secondary coil is resorted to, as illustrated in Fig. 2. I have found it from the outset convenient to make a departure from the ordinary ways of winding the coils with a considerable number of small turns. For many reasons the physician will find it better to provide a large hoop H of not less than, say, three feet in diameter and preferably more, and to wind upon it a few turns of stout cable P. The secondary coil S is easily prepared by taking two wooden hoops h h and joining them with stiff cardboard. One single layer of ordinary magnet wire, and not too thin at that, will be generally sufficient, the number of turns necessary for the particular use for which the coil is intended being easily ascertained by a few trials. Two plates of large surface, forming an adjustable condenser, may be used for the purpose of synchronizing the secondary with the primary circuit, but this is generally not necessary. In this manner a



FIGS. 1, 2, 3 AND 4.

cheap coil is obtained, and one which cannot be easily injured. Additional advantages, however, will be found in the perfect regulation which is effected merely by altering the distance between the primary and secondary, for which adjustment provision should be made, and, furthermore, in the occurrence of harmonics which are more pronounced in such large coils of thick wire, situated at some distance from the primary.

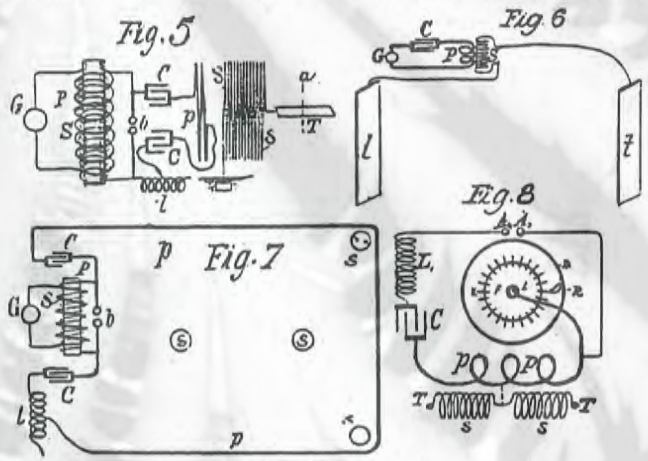
The preceding arrangements may also be used with alternating or interrupted currents of low frequency, but certain peculiar properties of high frequency currents make it possible to apply the latter in ways entirely impracticable with the former.

One of the prominent characteristics of high frequency or, to be more general, of rapidly varying currents, is that they pass with difficulty through stout conductors of high self-induction. So great is the obstruction which self-induction offers to their passage that it was found practicable, as shown in the early experiments to which reference has been made, to maintain differences of potential of many thousands of volts between two points—not more than a few inches apart—of a thick copper bar of inappreciable resistance. This observation naturally suggested the disposition illustrated in Fig. 3. The source of high frequency impulses is in this instance a familiar type of transformer which may be supplied from a generator G of ordinary direct or alternating currents. The transformer comprises a primary P, a secondary S, two condensers C C which are joined in series, a loop or coil of very thick wire L and a circuit interrupting device or break b. The currents are derived

[1]Read at the eighth annual meeting of The American Electro-Therapeutic Association, Buffalo, N. Y., Sept. 13 to 15, 1898.

from the loop L by two contacts c c', one or both of which are capable of displacement along the wire L. By varying the distance between these contacts, any difference of potential, from a few volts to many thousands, is readily obtained on the terminals or handles T T. This mode of using the currents is entirely safe and particularly convenient, but it requires a very uniform working of the break b employed for charging and discharging the condenser.

Another equally remarkable feature of high frequency impulses was found in the facility with which they are transmitted through condensers, moderate electromotive forces and very small capacities being required to enable currents of considerable volume to pass. This observation made it practicable to resort to a plan such as indicated in Fig. 4. Here the connections are similar to those shown in the preceding case, except that the condensers C C are joined in parallel. This lowers the frequency of the currents, but has the advantage of allowing the working with a much smaller difference of potential on the terminals of the secondary S. Since the latter is the chief item of expense of such apparatus and since its price rapidly increases with the number of turns required, the experimenter will find it generally cheaper to make a sacrifice in the frequency, which, however, will be high enough for most purposes. However, he only needs to reduce proportionately the number of turns or the length of primary p to obtain the same frequency as before, but the economy of transformation will be somewhat



FIGS. 5, 6, 7 AND 8.

reduced in so doing and the break b will require more attention. The secondary S' of the high frequency coil has two metal plates t t of considerable surface connected to its terminals, and the current for use is derived from two similar plates t' t' in proximity to the former. Both the tension and volume of the currents taken from terminals T T may be easily regulated and in a continuous manner by simply varying the distance between the two pair of plates t t and t' t' respectively.

A facility is also afforded in this disposition for raising or lowering the potential of one of the terminals T, irrespective of the changes produced on the other terminal, this making it possible to cause a stronger action on one or other part of the patient's body.

The physician may find it for some or other reason convenient to modify the arrangements in Figs. 2, 3 and 4 by connecting one terminal of the high frequency source to the ground. The effects will be in most respects the same, but certain peculiarities will be noted in each case. When a ground connection is made it may be of some consequence which of the terminals of the secondary is connected to the ground, as in high frequency discharges the impulses of one direction are generally preponderating.

Among the various noteworthy features of these currents there is one which lends itself especially to many valuable uses. It is the facility which they afford for conveying large amounts of electrical energy to a body entirely insulated in space. The practicability of this method of energy transmission, which is already receiving useful applications and promises to become of great importance in the near future, has helped to dispel the old notion assuming the necessity of a return circuit for the conveyance of electrical energy in any considerable amount. With novel appliances we are enabled to pass through a wire, entirely insulated on one end, currents strong enough to fuse it, or to convey through the wire any amount of energy to an insulated body. This mode of applying high frequency currents in medical treatment appears to me to offer the greatest possibilities at the hands of the physician. The effects produced in this manner possess features entirely distinct from those observed when the currents are applied in any of the before mentioned or similar ways.

The circuit connections as usually made are illustrated schematically in Fig. 5, which, with reference to the diagrams before shown, is self-expianatory. The condensers C C, connected in series, are preferably charged by a step-up transformer, but a high frequency alternator, static machine, or a direct current generator, if it be of sufficiently high tension to enable the use of small condensers, may be used with more or less success. The primary p, through which the high frequency discharges of the condensers are passed, consists of very few turns of cable of as low resistance as possible, and the secondary s, preferably at some distance from the primary to facilitate free oscillation, has one of its ends—that is the one which is nearer to the primary—connected to the ground, while the other end leads to an insulated terminal T, with which the body of the patient is connected. It is of importance in this case to establish synchronism between the oscillations in the primary and secondary circuits p and s respectively. This will be as a rule best effected by varying the self-induction of the circuit including the primary loop or coil p, for which purpose an adjustable self-induction e is provided; but in cases when the electromotive force of the generator is exceptionally high, as when a static machine is used and a condenser consisting of merely two plates offers sufficient capacity, it will be simpler to attain the same object by varying the distance of the plates.

The primary and secondary oscillations being in close synchronism, the points of highest potential will be on a part of terminal T, and the consumption of energy will occur chiefly there. The attachment of the patient's body to the terminal will in most cases very materially affect the period of oscillation in the secondary, making it longer, and a readjustment of the primary circuit will have to be made in each case to suit the capacity of the body connected with terminal T. Synchronism should always be preserved, and the intensity of the action varied by moving the secondary coil to or from the primary, as may be desired. I know of no method which would make it possible to subject the human body to such excessive electrical pressures as are practicable with this, or of one which would enable the conveying to and giving off from the body without serious injury amounts of electrical energy approximating even in a remote degree those which are entirely practicable when this manner of applying the energy is resorted to. This is evidently due to the fact that the action is chiefly superficial, the largest possible section being offered to the transfer of the current, or, to say more correctly, of the energy. With a very rapidly and smoothly working break I would not think it impossible to convey to the body of a person and to give off into the space energy at the rate of several horse power with impunity, while a small part of this amount applied in other ways could not fail to produce injury.

When a person is subjected to the action of such a coil, the proper adjustments being carefully observed, luminous streams are seen in the dark issuing from all parts of the body. These streams are short and of delicate texture when the number of breaks is very great and the action of the device b (Fig. 5) free of any irregularities, but when the number of breaks is small or the action of the device imperfect, long and noisy streams appear which cause some discomfort. The physiological effects produced with apparatus of this kind may be graduated from a hardly perceptible action when the secondary is at a great distance from the primary, to a most violent one when both coils are placed at a small distance. In the latter case only a few seconds are sufficient to cause a feeling of warmth all over the body, and soon after the person perspires freely. I have repeatedly, in demonstrations to friends, exposed myself longer to the action of the oscillations, and each time, after the lapse of an hour or so, an immense fatigue, of which it is difficult to give an idea, would take hold of me. It was greater than I experienced on some occasions after the most straining and prolonged bodily exertion. I could scarcely make a step and could keep the eyes open only with the greatest difficulty. I slept soundly afterward, and the after-effect was

glance this may seem a quite rational question. Our colleges teach us how to administer opium and its various derivatives, therefore the necessity for an opium society does not exist. but do our colleges teach us anything about electricity worthy of the subject? The answer to this question is quite unnecessary in the presence of the members of our association. Anyone should be depended upon to prescribe and administer the ordinary, or even extraordinary, remedies to carry out any regulation form of treatment. But I, for one, should fear to trust myself to the tender mercies of the general practitioner of to-day did he, in his wisdom, consider it necessary to use this agent, electricity, unless he had paid some special attention to the mastery of it. The contention is an absurdity unworthy of America, the vaunted land of progress, and of Buffalo, the Electrical City. In my own benighted land, even, we are more enlightened than that. This is an age of specialism.

"The old-time practitioner, then the physician and surgeon, seems passing away. Surgery is being divided and subdivided, until at one time we feared that we were to be confronted with an appendix surgeon. Our patients are reaping the benefit of all this. Why, then, should we call a halt? No! Let onward be our cry. The time is past when a physician, the proud possessor of a solitary magneto-electrical machine, turned by a crank, considered his armamentarium electricum quite complete. One has but to glance at our programme to see to what extent electricity may be used to advantage. A programme such as ours should prove a perfect revelation to him who has not kept well up to this progressive age. Could such a programme or one-hundredth part of it be intelligently discussed in any other existing society to-day not dealing distinctly with the subject? No, I greatly fear it would be a hidden book, a stumbling block.

"The hope of the future lies in those who are now thronging wisdom's halls, and it is a subject for congratulation that this association is to be asked to take action, bringing the needs of the hour before the authorities competent to deal with them. The student with mind as yet unwarped by prejudice must be in a position to obtain a comprehensive, intelligent grasp of the whole subject, that he may turn his theories to practical account in his professional career. But even he, unless endowed by these inestimable blessings, common sense, patience and gentleness, will find his efforts unavailing, and he must be a close observer of Nature and her laws, seeking to assist rather than to combat her. Electricity is an agent most powerful for weal or woe. A great responsibility rests upon our educators, and the sooner they awake from their strange lethargy the better will it be for our reputation as an enlightened, progressive, scientific profession. The commercial world has taken such advantage of the rapid strides of electricity as a science with fixed laws that we have laid ourselves open to the charge of neglect. Let us hasten to make amends for the past and remove some of the reproaches that rest on this, the noblest profession in this fair world.

"Our association was organized some eight years ago, because it was felt that the subject of electro-therapeutics could not be discussed in any existing society in a scientific and practical manner without controversial digressions of no value whatever. It was felt, and felt strongly, that electricity had been left too long to the charlatan, the incompetent and the unscrupulous. It was also felt that we had another foe of hardly less dangerous character, the over-zealous.

"To combat all these and cultivate and promote knowledge of electricity wherever it can be of service in medicine and surgery is the object of our association. It must be admitted that we are setting about this in the most practical manner possible. In fact, I know of no other association in which more practical or more useful work is being done. To carry out this idea successfully we have associated with us other than purely medical practitioners, and the association has proved a most happy one, and fruitful of nothing but good. Thus the electrical engineer and expert study electricity's laws and note its action upon inert matter. The biologist and physicist go a step farther and study these laws in their action upon living tissue, and their labors are turned to practical account by the physician and surgeon. The curative and palliative powers of the agent are available to all who have access to my clinics.

"The clouds are breaking on our horizon. On my side of that imaginary boundary line we find increasing interest being manifest, and it gives me the greatest satisfaction to say that my own warmest friends in the city of my adoption are the men who stand in the front ranks of medicine and surgery, and electrotherapy has a recognized standing, inasmuch as special departments devoted to it are to be found in our public hospitals. I have had the honor to organize and now to preside over four such departments in as many hospitals, and more intelligent inquiries are being made by the students of the various medical colleges, all of whom have access to my clinics.

"A rock we must avoid is that on which many a stronger society than our own has come to grief, the clique. And the furtherance of personal ambition or personal designs must be shunned."

All the suggestions embodied in the address were referred to the executive council of the association.

The programme for the afternoon was made up of a series of ten-minute talks on "Electro-Therapy," and the subject was one to attract a widespread interest among members of the medical fraternity.

Dr. G. Betton Massey, of Philadelphia, presented a paper on "The Galvanic Current in Gynaecology." The next paper was "Surgical Uses of Electricity," by Dr. Charles Rea Dickson, president of the association.

Dr. Robert Newman, of New York, presented a paper on "Electricity in Genito-Urinary Diseases." Dr. G. Betton Massey spoke on "Treatment of Malignant Growths by Means of Electricity."

A paper by Dr. Louis A. Weigel, of Rochester, on "Orthopædic Uses of Electricity," was followed by a paper by Dr. Rockwell on "Functional Diseases of the Nervous System Treated by Electricity."

The association adjourned at 4:30 p. m. and proceeded by special car to visit the power house and storage batteries of the Buffalo Railway Company.

A short business session of the American Electro-Therapeutic Association was held from 8 to 9 p. m., at which the following officers were elected: President, Dr. Francis B. Bishop, of Washington; first vice-president, Dr. Ernest Wende, of Buffalo; second vice-president, Dr. W. H. White, of Boston; secretary, Dr. John Gerin, of Auburn; treasurer, Dr. Richard T. Nunn, of Savannah, Ga.; executive council, Dr. Robert Newman, of New York, and Dr. G. Betton Massey, of Philadelphia, three years; Dr. A. D. Rockwell and Dr. William J. Morton, of New York, two years; Dr. Charles R. Dickson, of Toronto, and Dr. Frederick Schavoir, of Stamford, Conn., one year. Washington was selected for the convention next year, to be held September 19-21, 1899.

Dr. Lucien Howe entertained the men of the association at the conclusion of the business meeting. A smoker was given at Dr. Howe's home, corner of Delaware avenue and Huron street, which was largely attended.

THIRD DAY'S SESSIONS.

A vote of thanks was tendered to Dr. Wende, chairman of the local committee on arrangements; to the Buffalo Commercial for its kindness, not only during the convention, but in publishing the preliminary news of the association; to Dr. Howe, for his entertainment last evening; to Mayor Diehl, to the Buffalo Railway Company, Buffalo Historical Society, Fine Arts Academy, president and secretary of the association, and Dr. Newman, of New York, and to the press generally.

The congratulations of the American Electro-Therapeutic Association were extended to the University of Buffalo for its progress in establishing a chair of electro-therapeutics in the medical college.

A general vote of thanks was also adopted, expressing the association's deep appreciation of the courtesy and hospitality extended to the members during the convention in Buffalo.

At 10 o'clock the executive session adjourned and President Dickson called the scientific session to order. The first two papers on the programme were read by title. They were both by Drs. Georges Gautier and J. Larat, of Paris, France, the first on "The Hydro-Electric Bath with Sinusoidal Current in Disease," the second on "The Use of Hot Air and Light Bath in Disease."

A paper was read by the newly-elected president of the association, Dr. Francis B. Bishop, of Washington, on "Alternating Dynamo Currents."

Dr. Margaret A. Cleaves, of New York, read a paper on "The Electric Arc Bath."

A paper by Dr. J. H. Kellogg, of Battle Creek, Mich., on "The Electric Light Bath" was read by title. The next paper was by John J. Carty, of New York, on "Some Suggestions on

the Possibilities of Cataphoresis." Mr. Carty gave a short, practical talk, which was very interesting.

A paper by Dr. G. Herbert Burnham, of Toronto, Canada, on "Electricity in the Treatment of Certain Diseases of the Eye," was read by title.

Then came a paper by Nikola Tesla, read by Dr. White, of Boston. The subject was "A High Frequency Oscillator for Electro-Therapeutic Purposes."

The following papers were read by title: "The Effect of High Tension Discharges Upon Micro-Organisms," Drs. J. Inglis Parsons and C. Slater, London, England; "The Action of X-Rays Upon Tuberculosis," Dr. J. Bergonie, Bordeaux, France; "Two Years of Practice in Radiotherapy," Drs. Georges Gautier and J. Larat, Paris, France.

Dr. Newman, of New York, and Dr. Nunn, of Savannah, Ga., were appointed a committee by the president to conduct the president-elect, Dr. Bishop, of Washington, to the chair. Before turning over to his successor the gavel and other insignia of office Dr. Dickson took occasion to thank the association for its kindness and courtesy to him during his term of office.

The afternoon was devoted to an excursion and reception under the direction of the local committee of arrangements.

On Friday afternoon the members were conducted over the power house of the Niagara Falls Power Company by Coleman Sellers, E. D., president and chief engineer, who made the visit a most interesting and instructive one. On returning to the hotel a meeting was held and Dr. C. R. Dickson was requested to convey to Dr. Sellers the thanks of the association for his courtesy.

Those who remained visited on Saturday morning Power Station No. 2 of the Niagara Falls Hydraulic Power and Manufacturing Company, being conducted over it by the chief electrician, who fully explained all the appliances.

A most interesting exhibition of electrical apparatus for diagnostic, therapeutic and radiographic purposes was held in the room adjoining the meeting hall. The following manufacturers exhibited: Van Houten & Ten Broeck, New York; Chloride of Silver Dry Cell Battery Company, Baltimore, Md.; Jerome Kidder Manufacturing Company, New York; Edison Manufacturing Company, New York; Waite & Bartlett Company, New York; Dow Electric Assistant Company, Boston, Mass.; the American Electro-Neurotone Company, Niagara Falls, N. Y.; the Standard Cold Electric Lamp Company, Washington, D. C.; the Spencer Lens Company, Buffalo, N. Y.; the Detwiller, Biddle Company, Buffalo, N. Y.; W. J. Shields & Co., New Wilmington, Pa.; Rochester Fluorometer Company, Rochester, N. Y.

The eighth annual meeting was unanimously conceded the most successful and enjoyable that has been held, and the prospects for the association were never brighter or more encouraging.

certainly beneficial, but the medicine was manifestly too strong to be used frequently.

One should be cautious in performing such experiments for more than one reason. At or near the surface of the skin, where the most intense action takes place, various chemical products are formed, the chief being ozone and nitrogen compounds. The former is itself very destructive, this feature being illustrated by the fact that the rubber inslation of a wire is destroyed so quickly as to make the use of such insulation entirely impracticable. The compounds of nitrogen, when moisture is present, consists largely of nitric acid which might, by excessive application, prove hurtful to the skin. So far, I have not noted injuries which could be traced directly to this cause, though on several occasions burns were produced in all respects similar to those which were later observed and attributed to the Röntgen rays. This view is seemingly being abandoned, having not been substantiated by experimental facts, and so also is the notion that these rays are transverse vibrations. But while investigation is being turned in what appears to be the right direction, scientific men are still at sea. This state of things impedes the progress of the physicist in these new regions and makes the already hard task of the physician still more difficult and uncertain.

One or two observations made while pursuing experiments with the apparatus described might be found as deserving mention here. As before stated, when the oscillations in the primary and secondary circuits are in synchronism, the points of highest potential are on some portion of the terminal T. The synchronism being perfect and the length of the secondary coil just equal to one-quarter of the wave length, these points will be exactly on the free end of terminal T, that is, the one situated farthest from the end of the wire attached to the terminal. If this be so and if now the period of the oscillations in the primary be shortened, the points of highest potential will recede towards the secondary coil, since the wave-length is reduced and since the attachment of one end of the secondary coil to the ground determines the position of the nodal points, that is, the points of least potential. Thus, by varying the period of vibration of the primary circuit in any manner, the points of highest potential may be shifted accordingly along the terminal T, which has been shown, designedly, long to illustrate this feature. The same phenomenon is, of course, produced if the body of a patient constitutes the terminal, and an assistant may by the motion of a handle cause the points of highest potential to shift along the body with any speed he may desire. When the action of the coil is vigorous, the region of highest potential is easily and unpleasantly located by the discomfort or pain experienced, and it is most curious to feel how the pain wanders up and down, or eventually across the body, from hand to hand, if the connection to the coil is accordingly made—in obedience to the movement of the handle controlling the oscillations. Though I have not observed any specific action in experiments of this kind, I have always felt that this effect might be capable of valuable use in electro-therapy.

Another observation which promises to lead to much more useful results is the following: As before remarked, by adopting the method described, the body of a person may be subjected without danger to electrical pressures vastly in excess of any producible by ordinary apparatus, for they may amount to several million volts, as has been shown in actual practice. Now, when a conducting body is electrified to so high a degree, small particles, which may be adhering firmly to its surface, are torn off with violence and thrown to distances which can be only conjectured. I find that not only firmly adhering matter, as paint, for instance, is thrown off, but even the particles of the toughest metals are torn off. Such actions have been thought to be restricted to a vacuous inclosure, but with a powerful coil they occur also in the ordinary atmosphere. The facts mentioned would make it reasonable to expect that this extraordinary effect which, in other ways, I have already usefully applied, will likewise prove to be of value in electro-therapy. The continuous improvement of the instruments and the study of the phenomenon may shortly lead to the establishment of a novel mode of hygienic treatment which would permit an instantaneous cleaning of the skin of a person, simply by connecting the same to, or possibly, by merely placing the person in the vicinity of a source of intense electrical oscillations, this having the effect of throwing off, in a twinkle of the eye, dust or particles of any extraneous matter adhering to the body. Such a result brought about in a practicable manner would, without doubt, be of incalculable value in hygiene and would be an efficient and time-saving substitute for a water bath, and particularly appreciated by those whose contentment consists in undertaking more than they can accomplish.

High frequency impulses produce powerful inductive actions and in virtue of this feature they lend themselves in other ways to the uses of the electro-therapeutist. These inductive effects are either electrostatic or electrodynamic. The former diminish much more rapidly with the distance—with the square of the same—the latter are reduced simply in proportion to the distance. On the other hand, the former grow with the square of intensity of the source, while the latter increase in a simple proportion with the intensity. Both of these effects may be utilized for establishing a field of strong action extending through considerable space, as through a large hall, and such an arrangement might be suitable for use in hospitals or institutions of this kind, where it is desirable to treat a number of patients at the same time.

Fig. 6 illustrates the manner, as I have shown it originally, in which such a field of electrostatic action is established. In this diagram G is a generator of currents of very high frequency, C a condenser for counteracting the self-induction of the circuit which includes the primary P of an induction coil, the secondary S of which has two plates t t of large surface connected

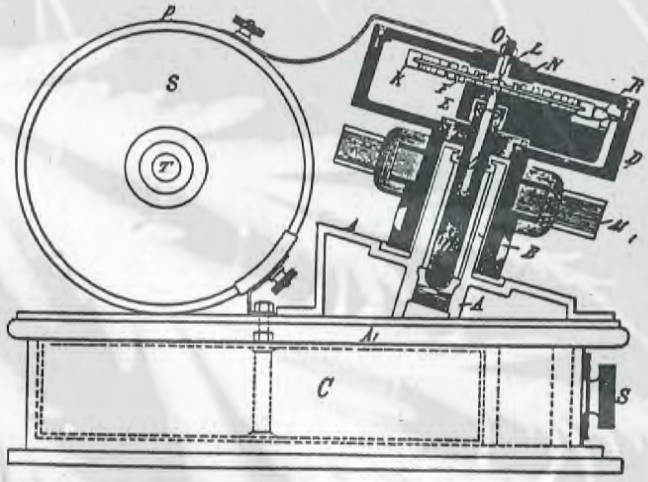


FIG. 9.

to its terminals. Well known adjustments being observed, a very strong action occurs chiefly in the space between the plates, and the body of a person is subjected to rapid variations of potential and surgings of current, which produce, even at a great distance, marked physiological effects. In my first experiments I used two metal plates as shown, but later I found it preferable to replace them by two large hollow spheres of brass covered with wax of a thickness of about two inches. The cables leading to the terminals of the secondary coil were similarly covered, so that any of them could be approached without danger of the insulation breaking down. In this manner the unpleasant shocks, to which the experimenter was exposed when using the plates, were prevented.

In Fig. 7 a plan for similarly utilizing the dynamic inductive effects of high frequency currents is illustrated. As the frequencies obtainable from an alternator are not as high as is desired, conversion by means of condensers is resorted to. The diagram will be understood at a glance from the foregoing description. It only need be stated that the primary p, through which the condensers are made to discharge, is formed by a thick stranded cable of low self-induction and resistance, and passes all around the hall. Any number of secondary coils s s s, each consisting generally of a single layer of rather thick wire, may be provided. I have found it practicable to use as many as one hundred, each being adjusted for a definite period and responding to a particular vibration passed through the primary. Such a plant I have had in use in my laboratory since 1892, and many times it has contributed to the pleasure of my visitors and also proved itself of practical utility. On a latter occasion I had the pleasure of entertaining some of the mem-

bers with experiments of this kind, and this opportunity I cannot let pass without expressing my thanks for the interest which was awakened in me by their visit, as well as for the generous acknowledgment of the courtesy by the Association. Since that time my apparatus has been very materially improved, and now I am able to create a field of such intense induction in the laboratory that a coil three feet in diameter, by careful adjustment, will deliver energy at the rate of one-quarter of a horse power, no matter where it is placed within the area inclosed by the primary loops. Long sparks, streamers and all other phenomena obtainable with induction coils are easily producible anywhere within the space, and such coils, though not connected to anything, may be utilized exactly as ordinary coils, and what is still more remarkable, they are more effective. For the past few years I have often been urged to show experiments in public, but, though I was desirous to comply with such requests, pressing work has so far made it impossible. These advances have been the result of slow but steady improvement in the details of the apparatus which I hope to be able to describe connectedly in the near future.

However remarkable the electrodynamic inductive effects, which I have mentioned, may appear, they may be still considerably intensified by concentrating the action upon a very small space. It is evident that since, as before stated, electromotive forces of many thousand volts are maintained between two points of a conducting bar or loop only a few inches long, electromotive forces of approximately the same magnitude will be set up in conductors situated near by. Indeed, I found that it was practicable in this manner to pass a discharge through a highly exhausted bulb, although the electromotive force required amounted to as much as ten or twenty thousand volts, and for a long time I followed up experiments in this direction with the object of producing light in a novel and more economical way. But the tests left no doubt that there was great energy consumption attendant to this mode of illumination, at least with the apparatus I had then at command, and, finding another method which promised a higher economy of transformation, my efforts turned in this new direction. Shortly afterward (some time in June, 1891,) Prof. J. J. Thomson described experiments which were evidently the outcome of long investigation, and in which he supplied much novel and interesting information, and this made me return with renewed zeal to my own experiments. Soon my efforts were centered upon producing in a small space the most intense inductive action, and by gradual improvement in the apparatus I obtained results of a surprising character. For instance, when the end of a heavy bar of iron was thrust within a loop powerfully energized, a few moments were sufficient to raise the bar to a high temperature. Even heavy lumps of other metals were heated as rapidly as though they were placed in a furnace. When a continuous band formed of a sheet of tin was thrust into the loop, the metal was fused instantly, the action being comparable to an explosion, and no wonder, for the frictional losses accumulated in it at the rate of possibly ten horse power. Masses of poorly conducting material behaved similarly, and when a highly exhausted bulb was pushed into the loop, the glass was heated in a few seconds nearly to the point of melting.

When I first observed these astonishing actions, I was interested to study their effects upon living tissues. As may be assumed, I proceeded with all the necessary caution, and well I might, for I had the evidence that in a turn of only a few inches in diameter an electromotive force of more than ten thousand volts was produced, and such high pressure would be more than sufficient to generate destructive currents in the tissue. This appeared all the more certain as bodies of comparatively poor conductivity were rapidly heated and even partially destroyed. One may imagine my astonishment when I found that I could thrust my hand or any other part of the body within the loop and hold it there with impunity. More than on one occasion, impelled by a desire to make some novel and useful observation, I have willingly or unconsciously performed an experiment connected with some risk, this being scarcely avoidable in laboratory experience, but I have always believed, and do so now, that I have never undertaken anything in which, according to my own estimation, the chances of being injured were so great as when I placed my head within the space in which such terribly destructive forces were at work. Yet I have done so, and repeatedly, and have felt nothing. But I am firmly convinced that there is great danger attending such an experiment, and some one going just a step farther than I have gone may be instantly destroyed. For, conditions may exist similar to those observable with a vacuum bulb. It may be placed in the field of the loop, however intensely energized, and so long as no path for the current is formed, it will remain cool and consume practically no energy. But the moment the first feeble current passes, most of the energy of the oscillations rushes to the place of consumption. If by any action whatever, a conducting path were formed within the living tissue or bones of the head, it would result in the instant destruction of these and death of the foolhardy experimenter. Such a method of killing, if it were rendered practicable, would be absolutely painless. Now, why is it that in a space in which such violent turmoil is going on living tissue remains uninjured? One might say the currents cannot pass because of the great self-induction offered by the large conducting mass. But this it cannot be, because a mass of metal offers a still higher self-induction and is heated just the same. One might argue the tissues offer too great a resistance. But this again cannot be the reason, for all evidence shows that the tissues conduct well enough, and besides, bodies of approximately the same resistance are raised to a high temperature. One might attribute the apparent harmlessness of the oscillations to the high specific heat of the tissue, but even a rough quantitative estimate from experiments with other bodies shows that this view is untenable. The only plausible explanation I have so far found is that the tissues are condensers. This only can account for the absence of injurious action. But it is remarkable that, as soon as a heterogeneous circuit is constituted, as by taking in the hands a bar of metal and forming a closed loop in this manner, the passage of the currents through the arms is felt, and other physiological effects are distinctly noted. The strongest action is, of course, secured when the exciting loop makes only one turn, unless the connections take up a considerable portion of the total length of the circuit, in which case the experimenter should settle upon the least number of turns by carefully estimating what he loses by increasing the number of turns, and what he gains by utilizing thus a greater proportion of the total length of the circuit. It should be borne in mind that, when the exciting coil has a considerable number of turns and is of some length, the effects of electrostatic induction may preponderate, as there may exist a very great difference of potential—a hundred thousand volts or more—between the first and last turn. However, these latter effects are always present even when a single turn is employed.

When a person is placed within such a loop, any pieces of metal, though of small bulk, are perceptibly warmed. Without doubt they would be also heated—particularly if they were of iron—when embedded in living tissue, and this suggests the possibility of surgical treatment by this method. It might be possible to sterilize wounds, or to locate, or even to extract metallic objects, or to perform other operations of this kind within the sphere of the surgeon's duties in this novel manner.

Most of the results enumerated, and many others still more remarkable, are made possible only by utilizing the discharges of a condenser. It is probable that but a very few—even among those who are working in these identical fields—fully appreciate what a wonderful instrument such a condenser is in reality. Let me convey an idea to this effect. One may take a condenser, small enough to go in one's vest pocket, and by skilfully using it he may create an electrical pressure vastly in excess—a hundred times greater if necessary—than any producible by the largest static machine ever constructed. Or, he may take the same condenser and, using it in a different way, he may obtain from it currents against which those of the most powerful welding machine are utterly insignificant. Those who are imbued with popular notions as to the pressures of static machines and currents obtainable with a commercial transformer, will be astonished at this statement—yet the truth of it is easy to see. Such results are obtainable, and easily, because the condenser can discharge the stored energy in an inconceivably short time. Nothing like this property is known in physical science. A compressed spring, or a storage battery, or any other form of device capable of storing energy, cannot do this; if they could, things undreamt of at present might be accomplished by their means. The nearest approach to a charged condenser is a high explosive, as dynamite. But even the most violent explosion of such a compound bears no comparison with the discharge or explosion of a condenser. For, while the pressures which are produced in the detonation of a chem-

ical compound are measured in tens of tons per square inch, those which may be caused by condenser discharges may amount to thousands of tons per square inch, and if a chemical could be made which would explode as quickly as a condenser can be discharged under conditions which are realizable—an ounce of it would quite certainly be sufficient to render useless the largest battleship.

That important realizations would follow from the use of an instrument possessing such ideal properties I have been convinced since long ago, but I also recognized early that great difficulties would have to be overcome before it could replace less perfect implements now used in the arts for the manifold transformations of electrical energy. These difficulties were many. The condensers themselves, as usually manufactured, were inefficient, the conductors wasteful, the best insulation inadequate, and the conditions for the most efficient conversion were hard to adjust and to maintain. One difficulty, however, which was more serious than the others, and to which I called attention when I first described this system of energy transformation, was found in the devices necessarily used for controlling the charges and discharges of the condenser. They were wanting in efficiency and reliability and threatened to prove a decided drawback, greatly restricting the use of the system and depriving it of many valuable features. For a number of years I have tried to master this difficulty. During this time a great number of such devices were experimented upon. Many of them promised well at first, only to prove inadequate in the end. Reluctantly, I came back upon an idea on which I had worked long before. It was to replace the ordinary brushes and commutator segments by fluid contacts. I had encountered difficulties then, but the intervening years in the laboratory were not spent in vain, and I made headway. First it was necessary to provide for a circulation of the fluid, but forcing it through by a pump proved itself impractical. Then the happy idea presented itself to make the pumping device an integral part of the circuit interrupter, inclosing both in a receptacle to prevent oxydation. Next some simple ways of maintaining the circulation, as by rotating a body of mercury, presented themselves. Then I learned how to reduce the wear and losses which still existed. I fear that these statements, indicating how much effort was spent in these seemingly insignificant details will not convey a high idea of my ability, but I confess that my patience was taxed to the utmost. Finally, though, I had the satisfaction of producing devices which are simple and reliable in their operation, which require practically no attention and which are capable of effecting a transformation of considerable amounts of energy with fair economy. It is not the best that can be done, by any means, but it is satisfactory, and I feel that the hardest task is done.

The physician will now be able to obtain an instrument suitable to fulfil many requirements. He will be able to use it in electro-therapeutic treatment in most of the ways enumerated. He will have the facility of providing himself with coils such as he may desire to have for any particular purpose, which will give him any current or any pressure he may wish to obtain. Such coils will consist of but a few turns of wire, and the expense of preparing them will be quite insignificant. The instrument will also enable him to generate Röntgen rays of much greater power than obtainable with ordinary apparatus. A tube must still be furnished by the manufacturers which will not deteriorate and which will allow to concentrate larger amounts of energy upon the electrodes. When this is done, nothing will stand in the way of an extensive and efficient application of this beautiful discovery which must ultimately prove itself of the highest value, not only at the hands of the surgeon, but also of the electro-therapist and, what is most important, of the bacteriologist.

To give a general idea of an instrument in which many of the latter improvements are embodied, I would refer to Fig. 9, which illustrates the chief parts of the same in side elevation and partially in vertical cross-section. The arrangement of the parts is the same as in the form of instrument exhibited on former occasions, only the exciting coil with the vibrating interrupter is replaced by one of the improved circuit breakers to which reference has been made.

This device comprises a casting A with a protruding sleeve B, which in a bushing supports a freely rotatable shaft a. The latter carries an armature within a stationary field magnet M and on the top, a hollow iron pulley D, which contains the break proper. Within the shaft a, and concentrically with the same, is placed a smaller shaft b, likewise freely movable on ball-bearings and supporting a weight E. This weight being on one side and the shafts a and b inclined to the vertical, the weight remains stationary as the pulley is rotated. Fastened to the weight E is a device R in the form of a scoop with very thin walls, narrow on the end nearer to the pulley and wider on the other end. A small quantity of mercury being placed in the pulley and the latter rotated against the narrow end of the scoop, a portion of the fluid is taken up and thrown in a thin and wide stream towards the centre of the pulley. The top of the latter is hermetically closed by an iron washer, as shown, this washer supporting on a steel rod L a disk F of the same metal provided with a number of thin contact blades K. The rod L is insulated by washers N from the pulley, and for the convenience of filling in the mercury a small screw o is provided. The bolt L forming one terminal of the circuit breaker is connected by a copper strip to the primary p. The other end of the primary coil leads to one of the terminals of the condenser C, contained in a compartment of a box A, another compartment of the same being reserved for switch S and terminals of the instrument. The other terminal of the condenser is connected to the casting A and through it to pulley D. When the pulley is rotated, the contact blades K are brought rapidly in and out of contact with the stream of mercury, thus closing and opening the circuit in quick succession. With such a device it is easy to obtain ten thousand makes and breaks per second and even more. The secondary s is made of two separate coils and so arranged that it can be slipped out, and a metal strip in its middle connects it to the primary coil. This is done to prevent the secondary from breaking down when one of the terminals is overloaded, as it often happens in working Röntgen bulbs. This form of coil will withstand a very much greater difference of potential than coils as ordinarily constructed.

The motor has both field and armature built of plates, so that it can be used on alternating as well as direct current supply circuits, and the shafts are as nearly as possible vertical, so as to require the least care in oiling. Thus, the only thing which really requires some attention is the commutator of the motor, but where alternating currents are always available, this source of possible trouble is easily done away with.

The circuit connections of the instrument have been already shown and the mode of operation explained in periodicals. The usual manner of connecting is illustrated in Fig. 8, in which A_1 A_2 are the terminals of the supply circuit, L, a self-induction coil for raising the pressure, which is connected in series with condenser C and primary P P. The remaining letters designate the parts correspondingly marked in Fig. 9 and will be understood with reference to the latter.

TELEGRAPHIC ADDRESS
"CROOKES, LONDON"

TO

FROM

WILLIAM CROOKES.

7, KENSINGTON PARK GARDENS,

LONDON, W.

March 5th, 1892.

My dear Tesla,

You are a true prophet. I have finished my new coil, and it does not do so well as the little one you made for me. I fear it is too large. I have fitted it with two sets of Leyden jars, six quart jars on each side, but the spark is not long or thick, and there is scarcely any brush to be seen. The phosphorescence through my body when I hold one terminal is decidedly inferior to that given with the little one. I am actuating it only with the ordinary make and break of the large coil, as the alternator is not yet here. I do not think I have made any mistake in the winding of the coil, as your coil does just the same as mine.

I hope you will get away to the mountains of your native land as soon as you can. You are suffering from over work, and if you do not take care of yourself you will break down. Don't answer this letter or see any one but take the first train. I am thinking of doing so myself, but I am only thinking of going as far as Hastings.

With our united kindest regards,

Believe me,

very sincerely yours,

William Crookes.

Oct 1 Mary Ann Tesla

630.595.4196
Nikola Skalic



VI

To the author of High Frequency Currents
from the Author of
This Book

Sincerely Yours
Nikola Tesla
Jan. 1910

MUZEJ
NIKOLE TESLE

Сигнатура	Писац
NT 207	Monell, S.H.
Инвентарни број	Наслов дела: HIGH FREQUENCY ELECTRIC CURRENTS IN MEDICINE AND DENTISTRY
207	Место и година издавања: New York, 1910

Датум узимања	Број читаоца	Потпис читаоца	Датум враћања	Параф библиот.



DRAWN BY JOSEPH PENNELL. LISSA.

slow boats which run between Trieste and Cattaro or Corfu, most of which lie up for several hours at each of the main island-harbors. In the end we decided, as we had done on several previous occasions, to try all the various ways among us, magnanimously assuming an unlimited liability for one another's impressions. It is a method which must be used with caution unless you know your partners very well. The only two guide-books of the Dalmatian coast which we had been able to procure in Vienna — that of Joanne and that of Hartleben — are in flagrant opposition to each other about most of the facts concerning the islands; and the sequel will show how near we ourselves came to finding what either of them had led us to expect.

The conclusion which we were finally forced to adopt was that neither of these authorities had visited the archipelago in person. They appear instead to have adopted the simpler plan of allowing "thought to play freely," in the words of Matthew Arnold, around some ancient series of prints of the Dalmatian coast and islands, idealized as it used to be thought obligatory to idealize in the days of Adam and Chapuy. At Lesina, for example, upon the island of the same name, a cheery, peaceful, and most inviting town, with an exquisite loggia fronting the principal quay, a harmless little citadel, and an amphitheater of softly swelling hills, we had been prepared for an *effet prodigieux* of precipitous peaks and frowning fortresses. At Curzola we were gravely informed by Joanne that we should find among other striking objects, all going to make up "a stage effect of the most surprising," . . . "an ancient bridge carried upon arches tall enough to admit the passage of full-masted barks." Will it be believed that there is not only no such bridge, but no tradition of any bridge whatever in the neighborhood of Curzola? The nearest approach is an extremely modest viaduct crossing a dry ditch, which it may once have been possible to flood, to a gateway in the fine town wall.

A favorite word both with Hartleben and Joanne, in depicting the aspect of the islands, is *amazing* — "*überraschend*" — "*surprenant*." But it is when one comes to compare their descriptions with the reality that the amazement properly comes in. Hartleben even goes so far as to give striking prints both of the bridge at Curzola and the beetling crags of Lesina; and the reader may find it amusing to compare his illustrations with the sketches of our own artist, who waves the banner and shouts



DRAWN BY JOSEPH PENNELL. SHIP-YARD, CURZOLA.

the watchword of Realism, in season and out of season, and is therefore bound to be veracious.

Meanwhile one of the prettiest and most characteristic features of Curzola, an extensive ship-yard overshadowed by venerable trees, where half the trading-boats that ply in these waters are constructed, seems to have escaped the notice of the guide-book makers altogether. Nor have they cared to let their fancy "play" to any great extent about either Lissa or Meleda, though each of these islands has interesting associations. It was off the former that the first proud navy of United Italy sustained so crushing a defeat at the hands of Admiral Tegetthoff in 1866, the bodies that were recovered after that fierce engagement having been all interred in the peaceful Campo Santo there; while Meleda, the southernmost of the four islands, prefers a plausible claim to have been the scene of St. Paul's shipwreck. For are we not explicitly informed that the island to which he escaped was called Melita? And our hearts will henceforth swell with a new sympathy for the apostle to the Gentiles whenever we read that the disaster took place after he had been "driven up and down in Adria."

(To be continued.)

Harriet Waters Preston.

TESLA'S OSCILLATOR AND OTHER INVENTIONS.

AN AUTHORITATIVE ACCOUNT OF SOME OF HIS RECENT ELECTRICAL WORK.[1]

SKOBELEFF, the great Russian general, once said of the political conditions in Central Asia, that they changed every moment; hence the necessity for vigilance, no less the price of empire than of liberty. Thus changeful, also, is the aspect of that vast new electrical domain which the thought and invention of our age have subdued. They who would inform themselves expertly about it, in whatever respect, must ever keep up an attitude of strained attention. Its theoretical problems assume novel phases daily. Its old appliances ceaselessly give way to successors. Its methods of production, distribution, and utilization vary from year to year. Its influence on the times is ever deeper, yet one can never be quite sure into what part of the social or industrial system it is next to thrust a revolutionary force. Its fanciful dreams of yesterday are the magnificent triumphs of to-morrow, and its advance toward domination in the twentieth century is as irresistible as that of steam in the nineteenth.

Throughout this change there has prevailed a consistency of purpose: a steady aim has been leveled at definite goals; while useful arts in multitude attest the solidity of the work done. If, therefore, we find a tremendous outburst of activity at the very moment when, after twenty-five years of superlative productiveness, electricians were ready, with the reforming English statesman, to rest and be thankful, we may safely assume that electricity has reached another of those crucial points at which it becomes worth the while of the casual outside observer to glance at what is going on. To the timid and the conservative, even to many initiated, these new departures have indeed become exasperating. They demand the unlearning of established facts, and insist on right-about-faces that disregard philosophical dignity. The sensations of a dog attempting to drink sea-water after a lifetime spent on inland lakes are feeble compared with those of men who discover that electricity is quite other than the fluid which they have believed it to be from their youth up, and that actually there is no such thing as electricity or an electric current.

Electricity has, indeed, taken distinctively new ground of late years; and its present state of unrest — unsurpassed, perhaps, in other regions of research — is due to recent theory and practice, blended in a striking manner in the discoveries of Mr. Nikola Tesla,[2] who, though not altogether alone, has come to be a foremost and typical figure of the era now begun. He invites attention to-day, whether for profound investigations into the nature of electricity, or for beautiful inventions in which is offered a concrete embodiment of the latest means for attaining the ends most sought after in the distribution of light, heat, and power, and in the distant communication of intelli-

[1] The photographs reproduced in this article were taken, under the special direction of the inventor, by Tonnele & Co.

[2] A biographical sketch of Mr. Tesla, by the present writer, with portrait, appeared in THE CENTURY for February, 1894.—EDITOR.

gence. Any one desirous of understanding the trend and scope of modern electrical advance will find many clues in the work of this inventor. The present article discloses a few of the more important results which he has attained, some of the methods and apparatus which he employs, and one or two of the theories to which he resorts for an explanation of what is accomplished.

By a brief preliminary survey, we may determine our historical longitude and latitude, and thus ascertain a little more precisely where we are. It is necessary to recapitulate facts known and accepted. Let it, then, be remarked that aside from the theories and interpretations that have beset the science, electricity as an art has for three hundred years been directed chiefly to securing an abundant, cheap, efficient, and economical supply of the protean agency, be it what it may. Frictional machine, Leyden jar, coil, battery, magnet, dynamo, oscillator,— these are but the steps in a process as regular and well-defined as those which take us from the aboriginal cradling of gold out of river sands up to the refining of ore with all the appliances of modern mechanism and chemistry. Each stage in electrical evolution has seen the conquest of some hitherto unknown art — electrotherapy, telegraphy, telephony, electric lighting, electric heating, power transmission; yet each has had limitations set on it by the conditions prevailing. With a mere battery much can be done; with a magnet, still more; with a dynamo, we touch possibilities of all kinds, for we compel the streams, the coal-fields, and the winds to do us service: but with Mr. Tesla's new oscillator we may enlist even the ether-waves, and turn our wayward recruits into resistless trained forces, sweeping across continents of unimagined opportunity.

The dynamo, slowly perfected these fifty years, has rendered enormous benefits, and is destined to much further usefulness. But all that we learn now about it of any intrinsic value is to build it bigger, or to specialize it; and the moment a device reaches that condition of development, the human intellect casts about for something else in which the elements are to be subtler and less gross. Based upon currents furnished by modern dynamo-electric machines, the arc-light and the trolley-car seek to monopolize street illumination and transportation, while the incandescent lamp has preempted for exclusive occupancy the interiors of our halls and homes. Yet the abandonment of gas, horses, and sails is slow, because the dynamo and its auxiliaries have narrow boundaries, trespassing which, they cease to offer any advantage. We can all remember the high hopes with which, for example, incandescent lighting was introduced some fifteen years ago. Even the most cynical detractor of it will admit that its adoption has been quick and widespread; but as a simple matter of fact, to-day, all the lamps and all the lighting dynamos in the country would barely meet the needs of New York and Chicago if the two cities were to use no other illuminant than electricity. In all England there are only 1,750,000 incandescent lamps contesting for supremacy with probably 75,000,000 gas-burners, and the rate of increase is small, if indeed it exceeds that of gas. Evidently, some factor is wanting, and a new point of departure, even in mere commercial work, is to be sought, so that with longer circuits, better current-generating apparatus, and lamps that will not burn out, the popular demand for a pure and perfect light can be met. In power transmission, also, unsatisfied problems of equal magnitude crop up. "Is there any load that water cannot lift?" asked Emerson. "If there be, try steam; or if not that, try electricity. Is there any exhausting of these means?" None, provided that our mechanics be right.

It must not be supposed that the new electricity is iconoclastic. In the minds of a great many people of culture the idea prevails that invention is as largely a process of pulling down as of building up; and electricity, in spreading from one branch of industry to another, encounters the prejudice that always rebuffs the innovator. The assumption is false. It may be true that in the gladiatorial arena where the principles of science contend, one party or the other always succumbs and drags out its dead; but in the arts long survival is the law for all the appliances that have been found of any notable utility. It simply becomes a question of the contracting sphere within which the old apparatus is hedged by the advent of the new; and that relation once established by processes complex and long continued, capable even of mathematical determination, the two go on together, complementary in their adjustment to specific human needs. In its latest outgrowths, electrical application exemplifies this. After many years' use of dynamo-electric machinery giving what is known as a "continuous current," the art has reached the conclusion that only with the "alternating current" can it fulfil the later duties laid upon it, and accomplish the earlier tasks that remain untouched. With the continuous current we have learned the rudiments of lighting and power distribution. With the alternating current, manipulated and coaxed to yield its highest efficiency, we may solve the problems of aërial and marine navigation by electricity, operate large railway systems, transmit the energy of Niagara hundreds of miles, and, in Mr. Tesla's own phrase, "hook our machinery directly to that of Nature."

THE GENERATION OF CURRENT.

LET us see wherein lies the difference between these two kinds of currents. In all dynamos the generation of what we call electric current is effected by the whirling of coils of wire in front of magnets, or conversely. The wires that lead away from the machine and back to it to complete the necessary circuit, may be compared to a circle of troughs or to a pipe-line; the coils and magnets are comparable to pump mechanism; and the lamps or motors driven by the current, to fountains or faucets spaced out on the trough circle. This comparison is crudity itself, but it gives a fairly exact idea. The current travels along the surface of the wire rather than inside, its magnetic or ether whorls resembling rubber bands sliding along a lead-pencil. A machine that produces continuous current, dipping its wire coils or buckets into the magnetic field of force, has all its jets, as they come around to discharge themselves, headed one way, and complicated devices called "commutators" have been unavoidable for the purpose of "rectifying" them. A machine that produces alternating currents, on the contrary, has its jets thrown first into one end of the trough system, and then into the other, and therefore dispenses with the rectifying or commutating valves. On the other hand, it requires peculiar adjustment of its fountains and faucets to the streams rushing in either way. It is an inherent disadvantage of the continuous-current system that it cannot deliver energy successfully at any great distance at high pressure, and that therefore the pipe-line must be relatively as bulky as were the hollow wooden logs which were once employed for water-conduits in New York. The advantage of the alternating current is that it can be delivered at exceedingly high pressures over very slender wires, and used either at that pressure or at lower or higher ones, obtained by means of a "transformer," which, according to its use, answers both to the idea of a magnetic reducing valve, and to that of a spring-board accelerating the rapidity of motion of any object alighting on it. Obviously a transformer cannot return more than is put into it, so that it gives out the current received with less pressure but in greater volume, or raised in pressure but diminished in the volume of the stream. In some like manner a regiment of soldiers may be brought by express to any wharf, and transferred, Indian file, to a sailing barge or an ocean liner indifferently; but throughout the trip the soldiers will constitute the same regiment, and when picked up by another train across the ferry, the body, though there be loss by desertion and sickness, will retain its identity, even if the ranks are broken in filling the cars, and are reformed four abreast at the end of the journey.

ALTERNATING CURRENTS.

LET us, still recapitulating familiar facts, make the next step in our review of what is involved in the resort to alternating currents. It was stated above that the current-consuming devices such as motors, likened to fountains, needed peculiar adjustments to the inflow first from one side and then from the other. Not to put it at all too strongly, they would not work, and have largely remained inoperative to the present time. Lamps would burn, but motors would not run, and this fact limited seriously the adoption and range of the otherwise flexible and useful alternating current until Mr. Tesla discovered a beautiful and unsuspected solution of the problem, and thus embarked on one part of the work now revealing grander possibilities every day. The transmission of the power of Niagara has become possible since the discovery of the method. In his so-called "rotating magnetic field," a pulley mounted upon a shaft is perpetually running after a magnetic "pole" without ever being able to catch it. The fundamental idea is to produce magnetism shifting circularly, in contrast with the old and known phenomenon of magnetism in a fixed position. Those who have seen the patient animal inside the treadmill wheel of the well at Carisbrooke Castle can form an idea of the ingenuity of Mr. Tesla's plan.

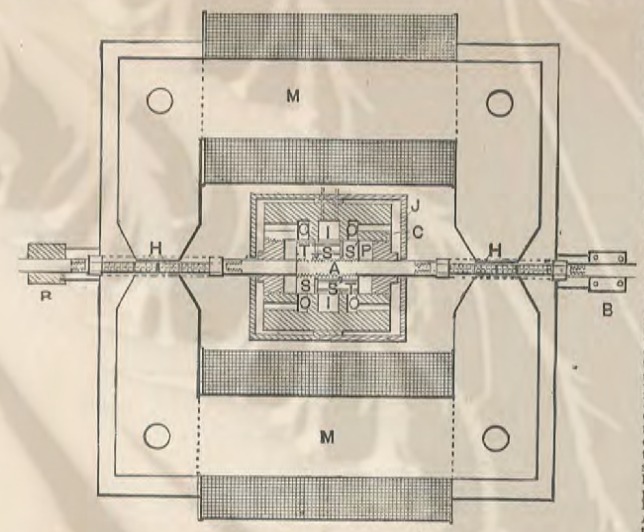
Ordinarily, alternating-current generators, such as are now in common use, have a great number of projecting poles to cause the alternations of current, and hence their "frequency" is high — that is, the current makes a great many to-and-fro motions per second, and each ebb-and-flow in the circuit is termed the "period" or "frequency," one alternation being the rise from zero to maximum value and down to nothing again, and the other the same thing backward. If we ruled a horizontal straight line, and then drew a round-bellied Hogarth curve of beauty across it, the half of the curve above the line would be illustrative of the positive flow, the lower half of the negative flow; the top of one oval and the bottom of the other oval would be the positive and negative maxima respectively; and the point where the curve crossed the straight line would mark the instant when the current changes its direction. A swinging pendulum is an analogy favored by scientists in their endeavors to illustrate popularly the process of the generation of the alternating current. Each time the copper wire in the coils on the dynamo armature is rotated past the pole of the dynamo field, the currents in each coil follow this rise and fall; so that the number

of the magnets and coils determines the period or frequency, as stated. The more numerous the magnets, and the faster the rotation of the coils, the quicker will be the ebbs and flows of current. But the character of the work to be done, and existing conditions, govern the rate at which the current is thus to be set vibrating; and no small amount of skill and knowledge enters here. The men who can predicate the right thing to do are still few and far between. The field has as yet been little explored. Moreover, in one of the deepest problems now engaging the thought of electrical engineers,—namely, the production of cheap light and cheap power by these new means,—opposite conditions pull different ways. Mr. Tesla made up his mind some time ago that for motor work it was better to have few frequencies; and the whole drift of power transmission is on that path, the frequency adopted for the work at Niagara being only twenty-five. But, as was natural, he ran through the whole scale of low and high frequencies, and soon discovered that for obtaining light, one great secret lay in the utilization of currents of high frequency and high potential. Some years ago, after dealing with the power problem as above described, Mr. Tesla attacked the light problem by building a number of novel alternating-current generators for the purpose, and attained with them alternations up to 30,000 per second. These machines transcended anything theretofore known in the art, and their currents were further raised in pressure by "step up" transformers and condensers. But these dynamos had their shortcomings. The number of the poles and coils could not be indefinitely increased, and there was a limit to the speed. To go to the higher frequencies, therefore, Mr. Tesla next invented his "disruptive discharge coil," which permitted him to reach remarkably high frequency and high pressure, and, what is more, to obtain these qualities from any ordinary current, whether alternating or continuous. With this apparatus he surprised the scientists both of this country and of Europe in a series of most interesting demonstrations. It is not too much to say that these experiments marked an epoch in electricity, yielding results which lie at the root of his later work with the oscillator in an inconceivably wider range of phenomena.

THE TESLA OSCILLATOR.

Up to this point we have been considering both continuous-current and alternating-current dynamos as driven by the ordinary steam-engine. Perhaps nine tenths of all the hundreds of thousands of dynamos in the world to-day are so operated, the remainder being driven by water-wheels, gas-engines, and compressed air. Now, each step from consuming the coal under the boilers that deliver steam to the engines, up to the glow of the filament in an incandescent lamp, is attended with loss. As in every other cycle that has to do with heat transformation, the energy is more or less frittered away, just as in July the load in an iceman's cart crumbles and melts in transit along the street. Actual tests prove that the energy manifesting itself as light in an incandescent lamp is barely five per cent. of that received as current. In the luminosity of a gas flame the efficiency is even smaller. Professor Tyndall puts the useful light-waves of a gas flame at less than one per cent. of all the waves caused by the combustion going on in it. If we were dealing with a corrupt city government, such wretched waste and inefficiency would not be tolerated; and in sad reality the extravagance is but on a par with the wanton destruction of whole forests for the sake of a few sticks of lumber. Armies of inventors have flung themselves on the difficulties involved in these barbaric losses occurring at every stage of the calorific, mechanical, and electric processes; and it is indeed likely that many lines of improvement have already been compelled to yield their utmost, reaching terminal forms. A moment's thought will show that one main object must be the elimination of certain steps in the transfer of the energy; and obviously, if engine and dynamo both have large losses, it will be a gain to merge the two pieces of apparatus. The old-fashioned electric-light station or street-railway power-house is a giddy maze of belts and shafting; in the later plants engine and dynamo are coupled directly together on one base. This is a notable stride, but it still leaves us with a dynamo in which some part of the wire wound on it is not utilized at every instant, and with an engine of complicated mechanism. The steam-cylinder, with its piston, is the only thing actually doing work, and all the rest of the imposing collection of fly-wheel, governor-balls, eccentrics, valves, and what not, is for the purpose of control and regulation.

In his oscillator Mr. Tesla, to begin with, has stripped the engine of all this governing mechanism. By giving also to the coils in which the current is created as they cut the "lines of force" of the magnets, a to-and-fro or reciprocating motion, so that the influence on them is equal in every direction, he has overcome the loss of the idle part of the wire experienced in rotating armatures; and, moreover, greatest achievement of all, he has made the currents regulate the mechanical motions. No matter how close the governing of the engine that drives the ordinary dynamo, with revolving armature, there is some irregularity in the generation of current. In the Tesla oscillator, if its inventor and the evidence of one's eyes may be



This form of oscillator has been used for experimental purposes, with air as the propelling force. It illustrates the principle of operation further developed in the machine shown in perspective in Fig. 2, in which steam is used as the propelling force. Outermost of all is seen the magnetic frame M M, built up of thin sheet-iron. This frame is wound with energizing coils of wire (indicated in hatchwork), as in ordinary electromagnets, and thus an intense magnetic "field of force" is concentrated on each side in the vicinity of H H, where are seen in dotted line two pairs of armature coils moving between the jaws of the inclosing electromagnets formed by M M. These armature coils, at H H, are supported on the shaft A, which runs through the piston P, and they, with the shaft, have additional bearings in the boxes B B at each end of the mechanism. The piston P is fitted into the hollow of the cylinder C, which in turn is inclosed by a jacket J, the latter serving chiefly to deaden the sound caused in working. The piston P is provided with channel-ports O O and I, which extend all around its inside surface. I is the inlet for the propelling compressed air, and O O are the outlets for the expanded air after its work is done at each stroke. In the piston P there are also two slots S S', while tubes T T are screwed into holes drilled in the piston. These tubes T T establish communication between the slots S S' and the chambers seen on each side of the piston, each chamber being thus connected with the slot which is remote from it. Now, the compressed air being brought through a delivery-pipe to the inlet I, with the piston P in the position it occupies in the diagram, and the shaft A being slightly touched so as to slide it a little to the left, the compressed air rushes through the slot S' and its communicating tube T, out into the chamber on the left of the piston. The pressure thus encountered by the piston on the left, from the expanding air, drives it back toward the right. Owing to its inertia, the piston thus impelled overshoots the position of equilibrium, allowing in this way the next supply of compressed air to rush from the inlet I into slot S and its tube T, and from them into the chamber on the right of the piston. Meantime the communication to the left-hand chamber is cut off, and the now expanded air there, having instantly done its work, escapes through the channel-port outlet O. As the piston now travels back from the right on the return stroke, a precisely similar operation takes place on the right-hand side of it, due to the expanding of the compressed air there and its subsequent quick escape as exhaust. In this manner, so long as compressed air is supplied, oscillation of the piston P is maintained at a very high rate, and with highest accuracy. The coils of fine wire mounted on shaft A, to which the piston P is firmly attached, are thus rapidly thrust to and fro by the shaft across the faces of, and in the space inclosed by, the jaws of the electromagnets at H H. In this manner they cut the so-called "lines" of the intense "field of force" at those two points, and currents are thus engendered in them, which are led off to the exterior circuit for use. These currents are "alternating" in their character, and are of high regularity. The maintenance of constancy of oscillation on the part of the piston P is also due to the reaction and steadying effect of this electromagnetic part of the combination. The "fitting-boxes" at the ends of the cylinder C inclosing the piston project a carefully determined distance into the cylinder, thus setting limits to the length of the stroke. It will be obvious to those familiar with such matters that steam could also be used in this type of oscillator, with slight adjustments.

FIG. 1. DIAGRAM OF WORKING PARTS OF EARLY FORM OF TESLA OSCILLATOR, AS IF SEEN FROM ABOVE, IN SECTION. (FROM "THE ELECTRICAL ENGINEER," BY PERMISSION.)

believed, the vibrations of the current are absolutely steady and uniform, so that one could keep the time o' day with the machine about as well as with a clock. It was this superlative steadiness of the vibration or frequency that Mr. Tesla aimed at, for one thing. The variations caused by the older apparatus might be slight, but minute errors multiplied by high rates of occurrence soon become perceptible, and militate against desirable uniformity and precision of action. Back of the tendencies to irregularity in the old-fashioned electrical apparatus were the equal or greater tendencies in the steam-engine; and over and above all were the frightful losses due to the inefficient conversion in both of the power released from the fuel under the boiler generating the steam.

Gain in one direction with a radical innovation usually means gain in many others, through a growing series. I confess I do not know which of the advantages of the oscillator to place first; and I doubt whether its inventor has yet been able to sit down and sum up all the realities and possibilities to which it is a key. One thing he does: he presses forward. Our illustration, Fig. 2, shows one of his latest forms of oscillator in perspective, while the diagram, Fig. 1, exhibits the internal mechanism of one of the early forms. Fig. 2 will serve as a text for the subsequent heads of discourse. The steam-chest is situated on the bed-plate between the two electromagnetic systems, each of which consists of field coils between which is to move the armature or coil of wire. There are two pistons to receive the impetus of the incoming steam in the chest, and in the present instance steam is supplied at a pressure of 350 pounds, although as low as 80 is also used in like oscillators, where steam of the higher pressure is not obtainable. We note immediately the absence of all the governing appliances of the ordinary engine. They are non-existent. The steam-chest *is* the engine, bared to the skin like a prize-fighter, with every ounce counting. Besides easily utilizing steam at a remarkably high pressure, the oscillator holds it under no less remarkable control, and, strangest of all, needs no packing to prevent leak. It is a fair inference, too, that, denuded in this way of superfluous weight and driven at high pressure, the engine must have an economy far beyond the common. With an absence of friction due to the automatic cushioning of the light working parts, it is also practically indestructible. Moreover, for the same pressure and the same piston speed the engine has about one thirtieth or one fortieth of the usual weight, and occupies a proportionately smaller space. This diminution of bulk and area is equally true of the electrical part. The engine-pistons carry at their ends the armature coils, and these they thrust reciprocatively in and out of the magnetic field of the field coils, thus generating current by their action.

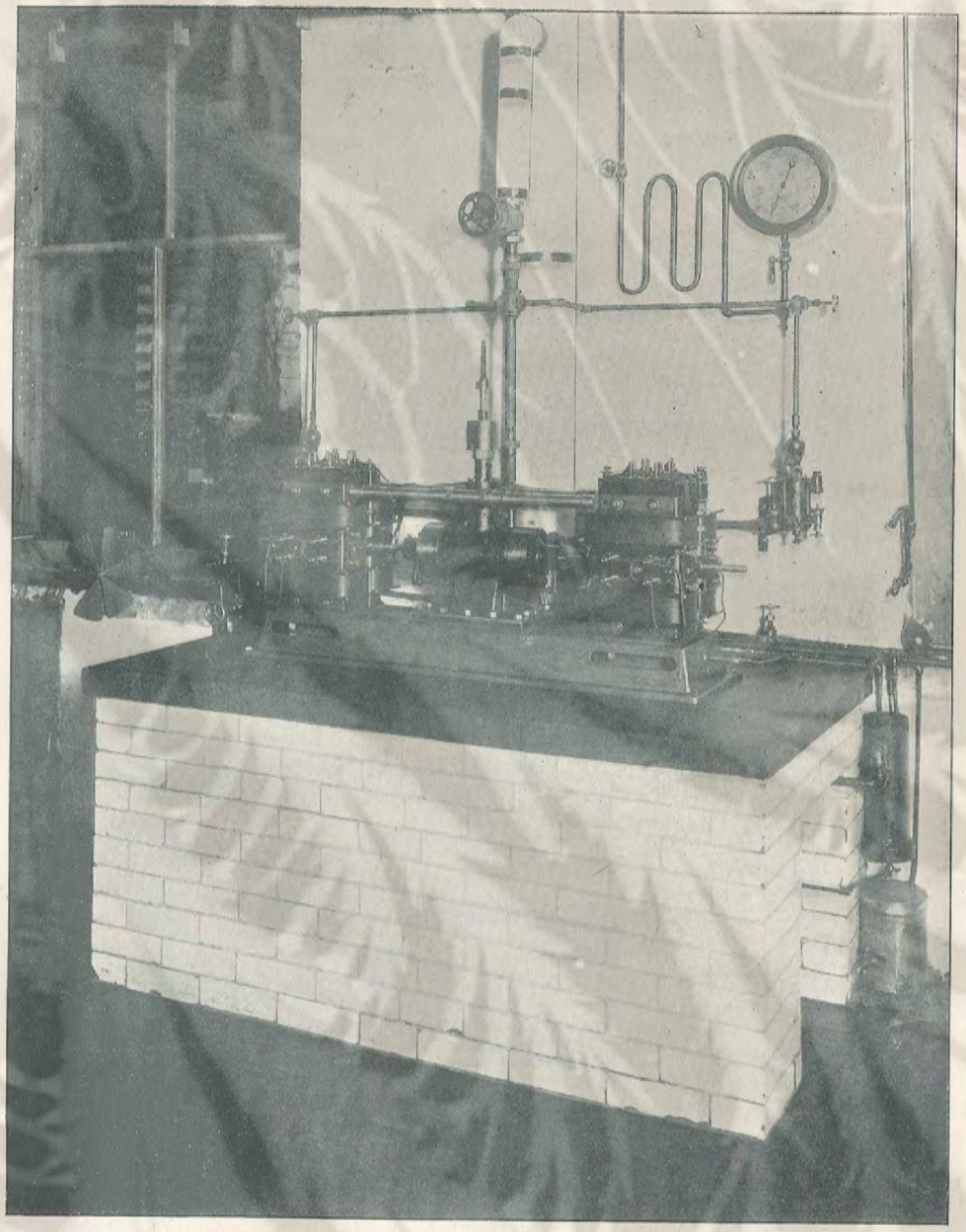


FIG. 2. LATEST FORM OF TESLA OSCILLATOR, COMBINING IN ONE MECHANISM DYNAMO AND STEAM-ENGINE.

If one watches any dynamo, it will be seen that the coils constituting the "armature" are swung around in front of magnets, very much as a turnstile revolves inside the barricading posts; and the current that goes out to do work on the line circuit is generated inductively in the coils, because they cut lines of influence emanating from the ends of the magnets, and forming what has been known since Faraday's time as the "field of force." In the Tesla oscillator, the rotary motion of the coils is entirely abandoned, and they are simply darted to and fro at a high speed in front of the magnets, thus cutting the lines of the "field of force" by shooting in and out of them very rapidly, shuttle-fashion. The great object of cutting as many lines of an intense field of force as swiftly, smoothly, regularly, and economically as possible is thus accomplished in a new and, Mr. Tesla believes, altogether better way. The following description of remarkable new phenomena in electricity will justify him in regard-



FIG. 3. FIRST PHOTOGRAPH EVER TAKEN BY PHOSPHORESCENT LIGHT. THE FACE IS THAT OF MR. TESLA, AND THE SOURCE OF LIGHT IS ONE OF HIS PHOSPHORESCENT BULBS. TIME OF EXPOSURE, EIGHT MINUTES. DATE OF PHOTOGRAPH JANUARY, 1894.

ing the oscillator as an extremely valuable instrument of research, while time will demonstrate its various commercial and industrial benefits.

Incidentally it may be remarked that the crude idea of obtaining currents by means of a coil or a magnetic core attached to the piston of a reciprocating steam-engine, is not in itself an entire novelty. It may also be noted that steam-turbines of extremely high rotative velocity are sometimes used instead of slow-moving engines to drive dynamos. But in the first class of long-abandoned experiments no practical result of any kind was ever reached before by any sort of device; and in the second class there is the objection that the turbine is driven by means of isolated shocks that cannot be overcome by any design of the blades, and which frustrate any attempts to perform work of the kind now under survey. What we are dealing with here is a dual, interacting machine, half mechanical, half electrical, of smallest bulk, extremely simple, utilizing steam under conditions unquestionably of the highest efficiency, its vibrations independent of load and pressure, delivering currents of the greatest regularity ever known for practical work or research. That such a combination should produce electricity for half the consumption of steam previously necessary with familiar apparatus in equivalent results, need not surprise us; yet think how much a saving of that kind would mean in well-nigh every industry consuming power!

THE OSCILLATOR AND THE PRODUCTION OF LIGHT.

HAVING obtained with the oscillator currents of high potential, high frequency, and high regularity, what shall be done with them? Mr. Tesla having already grappled successfully with the great difficulties of long distance power transmission, as narrated above, has first answered that question by boldly assailing the problem of the production of light in a manner nearer, perhaps, to that which gives us sunshine than was ever attempted before. Between us and the sun stretches the tenuous, sensitive ether, and every sensation of light that the eye experiences is caused by the effect of five hundred trillions of waves every second impressed on the ether by the molecular energy of the sun traveling along it rhythmically. If

the waves have a lower frequency than this 500,000,000,000,000, they will chiefly engender heat. In our artificial methods of getting light we imitatively agitate the ether so poorly that the waves our bonfires set up rarely get above the rate at which they become sensible to us in heat, and only a few waves attain the right pitch or rapidity to cause the sensation of light. At the upper end of the keyboard of vibration of the ether is a high, shrill, and yet inaudible note,—"light,"—which we want to strike and to keep on striking; but we fumble at the lower, bass end of the instrument all the time, and never touch that topmost note without wasting the largest part of our energy on the intermediate ones, which we do not at all wish to touch. Light (the high note) without heat (the lower notes) is the desideratum. The inefficiency of the gas flame has been mentioned. In the ordinary incandescent lamp the waste is not so great; but even there the net efficiency of any one hundred units of energy put into it as electric current is at the most five or six of light, the waste occurring in the process of setting the molecules of the filament and the little air left in the bulb into the state of vibration under which they must work before they can throw out energy-waves on the ether, which will be conveyed to us through the glass of the bulb by the ether as light rather than as heat. The glass is as unconfining to the ether as a coarse sieve is to water.

Now Mr. Tesla takes his currents of high frequency and high potential, subjects the incandescent lamp to them, and, skipping some of those intermediate wasteful heat stages of lower wave vibration experienced in the old methods, gets the ether-charged molecules more quickly into the intensely agitated condition necessary to yield light. Using his currents, produced electromagnetically, as we have seen, to load each fugitive molecule with its charge, which it receives and exercises electrostatically, he gets the ether medium into a state of excitement in which it seems to become capable of almost anything. In one of his first lectures, Mr. Tesla said:



FIG. 4. PHOSPHOGRAPH OF MR. CLEMENS (MARK TWAIN), TAKEN IN THE TESLA LABORATORY JANUARY, 1894. TIME OF EXPOSURE, TEN MINUTES.

> Electrostatic effects are in many ways available for the production of light. For instance, we may place a body of some refractory material in a closed, and preferably in a more or less air-exhausted, globe, connect it to a source of high, rapidly alternating potential, causing the molecules of the gas to strike it many times a second

at enormous speeds, and in this way, with trillions of invisible hammers, pound it until it gets incandescent. Or we may place a body in a very highly exhausted globe, and by employing very high frequencies and potentials maintain it at any degree of incandescence. Or we may disturb the ether carried by the molecules of a gas, or their static charges, causing them to vibrate or emit light.

These anticipatory statements are confirmed to-day by what Mr. Tesla has actually done in one old way revolutionized, and in three new ways: (1) the incandescence of a solid; (2) phosphorescence; (3) incandescence or phosphorescence of a rarefied gas; and (4) luminosity produced in a gas at ordinary pressure.

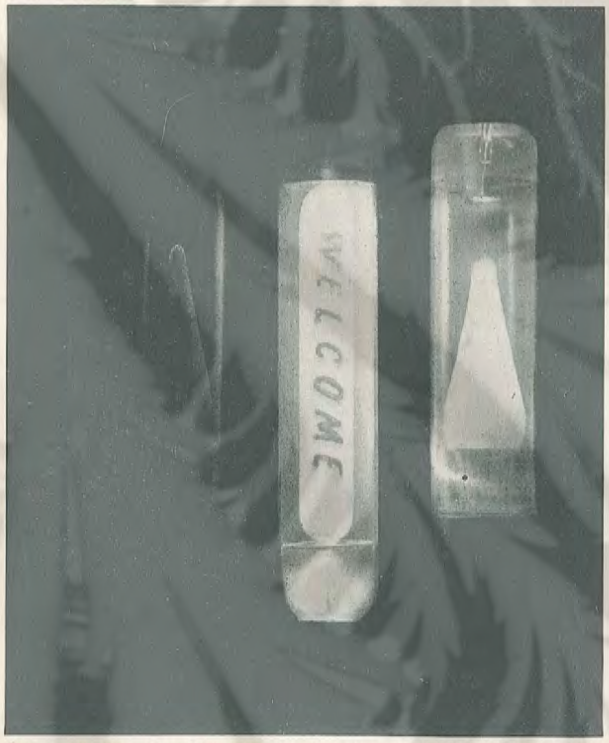


FIG. 5. THREE PHOSPHORESCENT BULBS UNDER TEST FOR ACTINIC VALUE. PHOTOGRAPHED BY THEIR OWN LIGHT.

LAMPS WITH BUTTONS OR BARS IN PLACE OF FILAMENTS.

TAKING lamps in the first category, it may be stated that it had been commonly supposed that the light-giving conductor in the lamp, to be efficient and practical, should be fine; hence the name "filament" given to the carbon loop in such lamps. But with the Teslaic currents the resistance or friction of the filament to the flow of current does not count for anything: the filament may just as well be short and thick, for it will rapidly reach and steadily maintain proper incandescence by the passage of a small current of the right high frequency and potential. An action is set up as the result of which the filament is hit millions of times a second by the bombardment of the molecules around it in a merciless ring of tormentors. The vibrations of the current in similar manner will cause the infinite jostling of the molecules of solid and gas against a small polished carbon or metallic button or bar in a lamp, and brilliant light is also obtainable in this way.

LIGHT AND PHOTOGRAPHS WITH TESLA PHOSPHORESCENT BULBS.

IN the field of lighting by phosphorescence we reach hitherto untrodden ground. Phosphorescent light has been associated with the idea of "cold light," or the property of becoming luminous with the omission of the intermediate step of combustion, as commonly understood. As a physical action, we know it in the light of the firefly, which Professor S. P. Langley rates at an efficiency of 100 per cent., all its radiations lying within the limits of the visible spectrum. By means of the Teslaic currents phosphorescent light strong enough even to photograph by has been obtained; and Fig. 3, representing the inventor himself, is the first portrait or photograph of any kind ever taken by phosphorescent light. A bulb whose light-giving member is coated with sulphide of zinc treated in a special way was rendered phosphorescent by means of current obtained from a high-frequency transformer coil. The current used was alternated or oscillated about 10,000 times per second. The exposure was about eight minutes.

Fig. 4, of Mr. Clemens (Mark Twain), was taken a few weeks later — early in 1894 — with the aid of the same bulb, and with an exposure of about ten minutes. In order to test more closely the actinic value of phosphorescent light, some bulbs subject to high-frequency currents were photographed, or, if we may coin a new word, "phosphographed," with a somewhat longer exposure. They are shown in Fig. 5. The right-hand, bright pair utilize sulphide of zinc in some form for luminosity. The third bulb, seen faintly to the left of them, has a coating of sulphide of calcium. Although, judged by the eye, it glowed with a brightness fully equal to that of the other two, the actinic value was

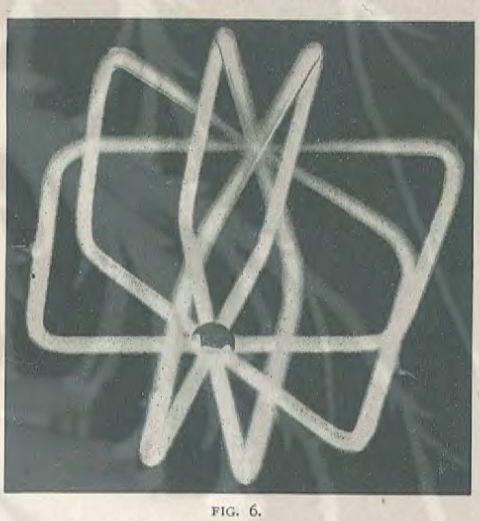


FIG. 6.

FIGS. 6, 7, AND 8 ARE TESLA TUBES OF DIFFERENT FORMS IN WHICH LIGHT IS OBTAINED WITHOUT FILAMENT OR COMBUSTION. (PHOTOGRAPHED BY THEIR OWN LIGHT.)

evidently much less. It is, perhaps, needless to say that these demonstrations invite to an endless variety of experiments, in which investigators will find a host of novel phenomena awaiting them as to phosphorescence and fluorescence produced with electrical currents.

LIGHT FROM EMPTY BULBS IN FREE SPACE.

THE third and fourth classes of lighting enumerated above as obtained by Teslaic currents are those caused by the incandescence or phosphorescence of a rarefied gas and the luminosity of a gas at ordinary pressure. We get pure, beautiful light without any filament or any combustion. In Figs. 6, 7, and 8 we have tubes or bulbs by means of which some of these interesting phenomena are obtained and illustrated. The bulbs shown are more or less exhausted of air. In the case of Figs. 6 and 7 the glass of the tubes is the ordinary German glass. In Fig. 8, uranium glass—green—was employed. This last was held in the hand while a photograph was taken of it by its own light; whence the unsteadiness of the negative. To obtain the beautiful illumination seen in all three, the bulbs were simply approached within a few inches of the terminal of a high-frequency coil or transformer. Just here it may be pointed out that the lamps are spoken of as unattached, in free space. Ordinary incandescent lighting is done, as everybody knows, with the lamps' bases firmly attached to the two current-bearing wires. Even where the lamps have been used on the ordinary alternating circuits in which the transformer is employed to "step down," or reduce, for safe use, the higher-tension current brought to it by the wire from the dynamo, the lamps have to be attached to the "secondary" wires of the coil so as to make a closed circuit for



FIG. 8.

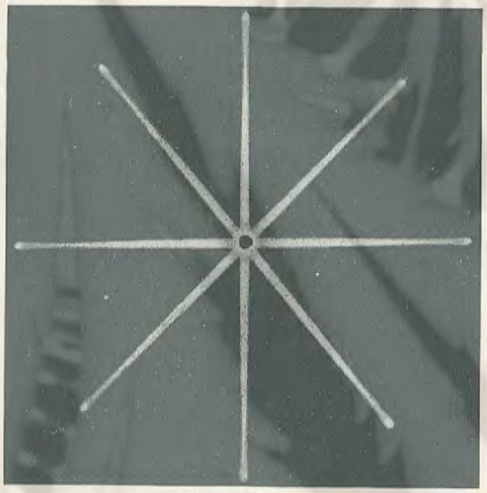


FIG. 7.

them. But as we rise in the frequency of the current, as we leave behind the electrodynamic conditions for the electrostatic ones, so we free ourselves from the restrictions and limitations of solid wires for the conveyance of the effects sought, until at last we reach a point where all the old ideas of the necessity of a tangible circuit vanish. It is all circuit if we can properly direct the right kind of impulses through it. As Mr. Tesla long ago pointed out, most of the experiments usually performed with a static machine of glass plates can also be performed with an induction-coil of wire if the currents are alternated rapidly enough; and it is in reality here that Mr. Tesla parts company with other distinguished workers who have fixed their attention merely on the results attainable with electrodynamic apparatus. Before passing on, let us quote the inventor himself:

Powerful electrostatic effects are a *sine quâ non* of light production on the lines indicated by theory. Electromagnetic effects are primarily unavailable, for the reason that to produce the required effects

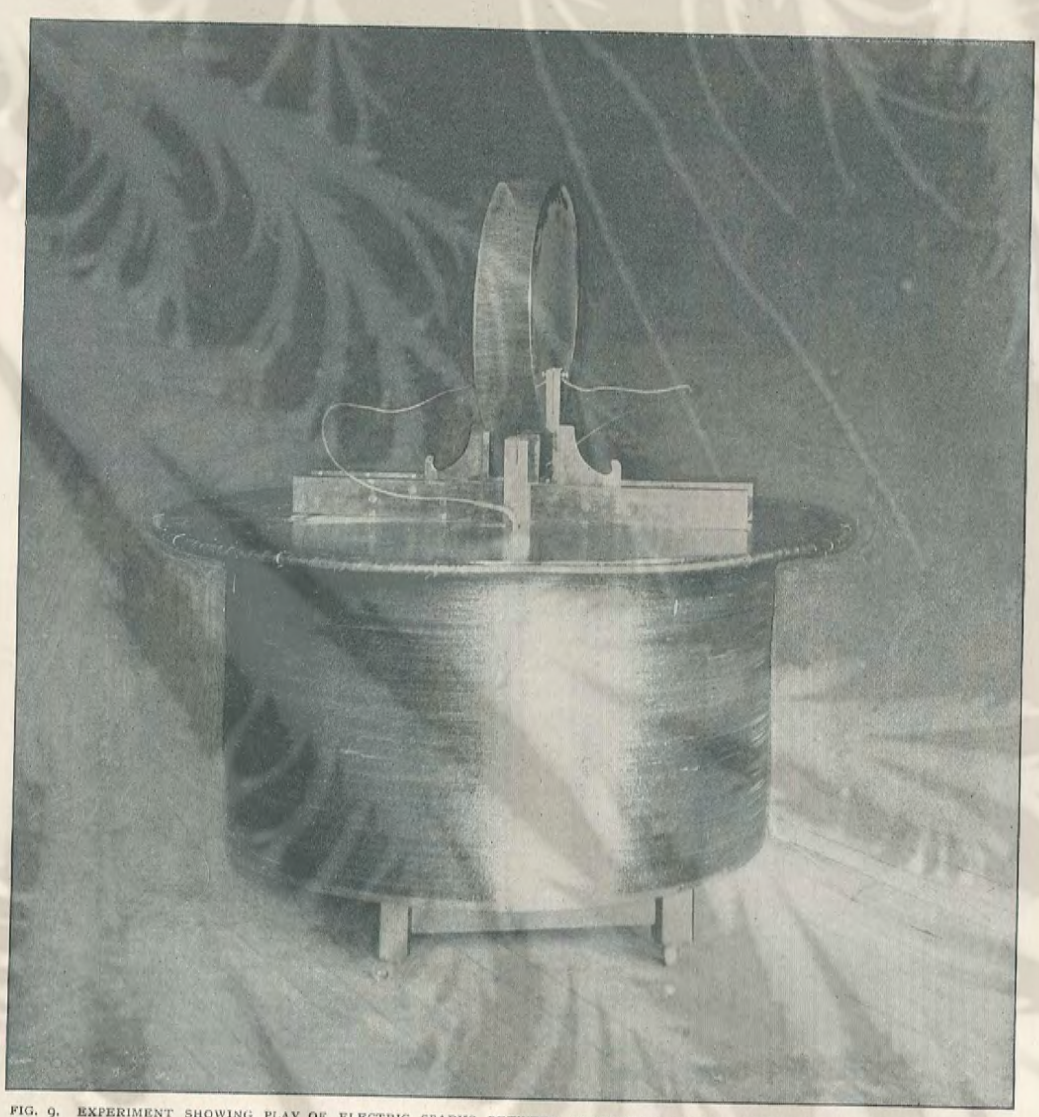


FIG. 9. EXPERIMENT SHOWING PLAY OF ELECTRIC SPARKS BETWEEN CONDENSER PLATES, PRODUCED BY ELECTRIC CHARGE. THE COIL, STANDING IN THE CENTER OF A LARGE ROOM, IS UNCONNECTED WITH THE ENERGIZING CIRCUIT. (FROM FLASH-LIGHT PHOTOGRAPH.)

we would have to pass the current impulses through a conductor which, long before the required frequency of the impulses could be reached, would cease to transmit them. On the other hand, electromagnetic waves many times longer than those of light, and producible by sudden discharge of a condenser, could not be utilized, it would seem, unless we availed ourselves of their effect upon conductors as in the present methods, which are wasteful. We could not affect by means of such waves the static molecular or atomic charges of a gas, and cause them to vibrate and to emit light. Long transverse waves cannot, apparently, produce such effects, since excessively small electromagnetic disturbances may pass readily through miles of air. Such dark waves, unless they are of the length of true light-waves, cannot, it would seem, excite luminous radiation in a Geissler tube, and the luminous effects which are producible by induction in a tube devoid of electrodes, I am inclined to consider as being of an electrostatic nature. To produce such luminous effects straight electrostatic thrusts are required; these, whatever be their frequency, may disturb the molecular charges and produce light.

EFFECTS WITH ATTUNED BUT WIDELY SEPARATED CIRCUITS.

A FEW experiments performed in Mr. Tesla's laboratory workshop afford an idea of the flexibility of the methods by which powerful electrostatic effects are produced across many feet of intervening space. The workshop is a room about forty by eighty feet, and ten or twelve feet

high. A circuit of small cable is carried around it from the terminals of the oscillator. In the center of the clear, open space is placed a coil, wound drum fashion, three or four feet high, and unconnected with the current source save through the medium of the atmosphere. The coil is provided, as shown in the picture, with two condenser plates for adjustment, standing up like cymbals. The plates act after the manner of a spring, and the coil is comparable to an electromagnetic weight. The system of apparatus in the middle of the room has therefore a certain period of vibration, just as though it were a tuning-fork, or a sheet of thin resonant glass. Around the room, over the cable, there are sent from the oscillator electrical current vibrations. By carefully adjusting the condenser plates so that the periodicity or swing of the induced current is brought into step with that of the cable currents, powerful sparks are made to pour across between the plates in the dense streams shown in Fig. 9. In this manner it is easy to reach tensions as high as 200,000 and 300,000 volts.

No one who has witnessed these significant experiments can fail to be impressed with the evidence of the actuality of a medium, call it ether or what you will, which in spite of its wonderful tenuity is as capable of transmitting energy as though it were air or water. Still more impressive to a layman, perhaps, is the confidence and easy precision with which these fine adjustments are brought about.

In Fig. 10 there is a similar coil, in the middle of the same room, which has been so adjusted to the vibrations sent around the shop that an ordinary sixteen-candle-power incandescent lamp is well lighted up.

Fig. 11 pursues this a little further. Above the coil a circle of wire is held by an observer, and an incandescent lamp is attached to the circle. As before, the vibration of the ether in the coil is brought into harmony with the vibrations emitted from the cable. The inductive effect upon the circle held loosely in free space by the observer is so pronounced that the lamp is immediately lighted up, though it may be connected with but one terminal wire, or with two. A 100-volt lamp is used, requiring when employed ordinarily more than one tenth of a horse-power right off the connecting circuit wires direct from the dynamo to bring it up to proper illuminating value. Hence, as will be seen, there is actual proof here of the transmission of at least that amount of energy across a space of some twenty feet and into the bulb by actually no wire at all. This need not surprise us when we remember that on a bright day the ether delivers steadily from the sun a horse-power of energy to every seven square feet of the earth's

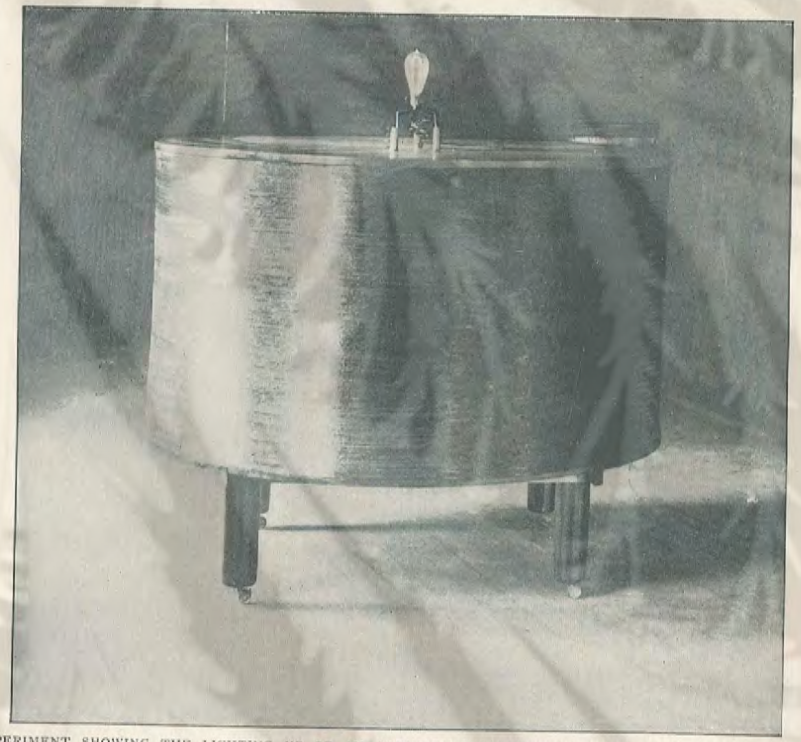


FIG. 10. EXPERIMENT SHOWING THE LIGHTING UP OF AN ORDINARY INCANDESCENT LAMP, AT A DISTANCE, THROUGH THE INFLUENCE OF ELECTRIFIED ETHER-WAVES. (FROM FLASH-LIGHT PHOTOGRAPH.)

surface toward it: so great is its capacity for transmitting energy. Mr. Tesla with his "electrostatic thrusts" has simply learned the knack of loading electrically on the good-natured ether a little of the protean energy of which no amount has yet sufficed to break it down or put it out of temper. We may assume either an enormous speed in what may be called the transmitting wheelwork of the ether, since the weight is inconceivably small; or else that the ether is a mere transmitter of energy by its well-nigh absolute incompressibility.

CURIOUS "IMPEDANCE" PHENOMENON.

IN Fig. 12 we have another remarkable experiment illustrated. Standing over the coil in the center of the room, the observer holds a hoop of stout wire in his hand. One or more lamps are connected with two points on the wire, so that the lamps are "short-circuited" by the short bar of wire. The vibrations are, however, so extremely rapid that in spite of the opposite terminals being united in this way, the current does not flow past them neglectfully, in the apparently easier path, as it should, but brings them to a bright incandescence. We have here an example of what is known as "impedance" phenomena, in which the current is oddly choked back at certain points and not at others. Under the conditions of "impedance," the best electrical conductor loses its property of conducting, and behaves like a highly resisting substance. Elaborating further these experimental results, Mr. Tesla shows that a gas — a perfect non-conductor under ordinary circumstances — may be more conductive than the best copper wire, provided the currents vibrate rapidly enough. The fantastic side of this phenomenon he touched on playfully once by suggesting that perchance in such wise we might some day utilize gas to convey electricity, and the old gas-pipe to insulate it.



FIG. 11. EXPERIMENT ILLUSTRATING THE LIGHTING OF AN INCANDESCENT LAMP IN FREE SPACE BY INDUCTION FROM COIL BELOW, ENERGIZED BY DISTANT CIRCUIT AROUND THE ROOM. THE LOOP OF WIRE CARRVING THE LAMP IS HELD BY MR. MARION CRAWFORD. (FROM FLASH-LIGHT PHOTOGRAPH.)

LAMPS LIGHTED BY CURRENTS PASSED THROUGH THE HUMAN BODY.

IN Fig. 13 a most curious and weird phenomenon is illustrated. A few years ago electricians would have considered it quite remarkable, if indeed they do not now. The observer holds a loop of bare wire in his hands. The currents induced in the loop by means of the "resonating" coil over which it is held, traverse the body of the observer, and at the same time, as they pass between his bare hands, they bring two or three lamps held there to bright incandescence. Strange as it may seem, these currents, of a voltage one or two hundred times as high as that employed in electrocution, do not inconvenience the experimenter in the slightest. The extremely high tension of the currents which Mr. Clemens is seen receiving prevents them from doing any harm to him.

TRANSMISSION OF INTELLIGENCE BY ATTUNED OR "RESONATING" CURRENTS.

REFERENCE has been made to the "resonating" quality of the circuits and coils. It would be



FIG. 12. SIMILAR EXPERIMENT, ILLUSTRATING THE PHENOMENON OF IMPEDANCE. THE LOOP OF WIRE, CARRYING TWO LAMPS, IS HELD BY MR. JOSEPH JEFFERSON. (FROM FLASH-LIGHT PHOTOGRAPH.)

wearisome, and indeed is not necessary, here to dwell on the difficulty often experienced in establishing the relation of "resonance," and the instantaneity with which it can be disturbed. It may be stated, in order to give some idea of the conditions to be observed in these experiments, that when an electric circuit is traversed by a rapidly oscillating current which sets up waves in the ether around the wire, the effect of these waves upon another circuit situated at some distance from the first can be largely varied by proper adjustments. The effect is most pronounced when the second circuit is so adjusted that its period of vibration is the same as that of the first. This harmonizing is deftly accomplished by varying either of the two elements which chiefly govern the rapidity of the vibration, viz., the so-called "capacity" and the "self-induction." Whatever the exact process may be, it is clear that these two quantities in their effect answer almost directly to what are known in mechanics as pliability and as weight or inertia. Attach to a spring a weight, and it will vibrate at a certain rate. By changing the weight, or modifying the pliability of the spring, any period of vibration is obtainable. In very exact adjustments, minute changes will completely upset the balance, and the very last straw of fine wire, for example, in the induction-coil which gives the self-induction will break the spell. As Mr. Tesla has said, it is really a lucky thing that pure resonance is not obtainable; for if it were, all kinds of dangers might lie in store for us by the increasing oscillations of every kind that would be set up. It will, however, have been gathered that if one electrical circuit can be tuned to another effectively, we shall need no return wire, as heretofore, for motors or for lights, the one wire being, if anything, better than two, provided we have vibration of the right value; and if we have that, we might get along without any wires or any "currents." Here again we must quote Mr. Tesla:

In connection with resonance effects and the problem of transmission of energy over a single conductor, I would say a few words on a subject which constantly fills my thoughts, and which concerns the welfare of all. I mean the transmission of intelligible signals, or perhaps even power, to any distance without the use of wires. I am becoming daily more convinced of the practicability of the scheme; and though I know full well that the majority of scientific men will not believe that such results can be practically and immediately realized, yet I think that all consider the develop-



FIG. 13. SIMILAR EXPERIMENT, THE HIGH-TENSION CURRENT BEING PASSED THROUGH THE BODY BEFORE IT BRINGS THE LAMPS TO INCANDESCENCE. THE LOOP IS HELD OVER THE RESONATING COIL BY MR. CLEMENS (MARK TWAIN). (FROM A FLASH-LIGHT PHOTOGRAPH.)



FIG. 14. EFFECT OF ELECTRICAL DISCHARGE FROM THE EARTH BY TESLA COIL. (PHOTOGRAPHED BY ITS OWN LIGHT.)

ments of recent years by a number of workers to have been such as to encourage thought and experiment in this direction. My conviction has grown so strong that I no longer look upon this plan of energy or intelligence transmission as a mere theoretical possibility, but as a serious problem in electrical engineering which must be carried out some day. The idea of transmitting intelligence without wire is the natural outcome of the most recent results of electrical investigations. Some enthusiasts have expressed their belief that telephony to any distance by induction through the air is possible. I cannot stretch my imagination so far; but I do firmly believe that it is practicable to disturb by means of powerful machines the electrostatic condition of the earth, and thus transmit intelligible signals and perhaps power. In fact, what is there against the carrying out of such a scheme? We now know that electric vibration may be transmitted through a single conductor. Why, then, not try to avail ourselves of the earth for this purpose? We need not be frightened by the idea of distance. To the weary wanderer counting the mile-posts the earth may appear very large; but to that happiest of all men, the astronomer, who gazes at the heavens, and by their standard judges the magnitude of our globe, it appears very small. And so I think it must seem to the electrician; for when he considers the speed with which an electric disturbance is propagated through the earth, all his ideas of distance must completely vanish. A point of great importance would be first to know what is the capacity of the earth, and what charge does it contain of electricity.

DISTURBANCE AND DEMONSTRATION OF THE EARTH'S ELECTRICAL CHARGE.

PART of Mr. Tesla's more recent work has been in the direction here indicated; for in his oscillator he has not simply a new practical device, but a new implement of scientific research. With the oscillator, if he has not as yet actually determined the earth's electrical charge or "capacity," he has obtained striking effects which conclusively demonstrate that he has succeeded in disturbing it. He connects to the earth, by one of its ends, a coil (see Fig. 15) in which rapidly vibrating currents are produced, the other end being free in space. With this coil he does actually what one would be doing with a pump forcing air into an elastic football. At each alternate stroke the ball would expand and contract. But it is evident that such a ball, if filled with air, would, when suddenly expanded or contracted, vibrate at its own rate. Now if the strokes of the pump be so timed that they are in harmony with the individual vibrations of the ball, an intense vibration or surging will be obtained. The purple streamers of electricity thus elicited from the earth and pouring out to the ambient air are marvelous. Such a display is seen in Fig. 14, where the crown of the coil, tapering upward in a Peak of Teneriffe, flames with the outburst of a solar photosphere.

The currents which are made to pass in and out of the earth by means of this coil can also be directed upon the human body. An observer mounted on a chair, and touching the coil with a metal rod, can, by careful adjustments, divert enough of it upon himself to cause its manifestation from and around him in splinters of light. This halo effect, obtained by sending the electricity of the earth through a human being,—the highest charge positively ever given in safety,—

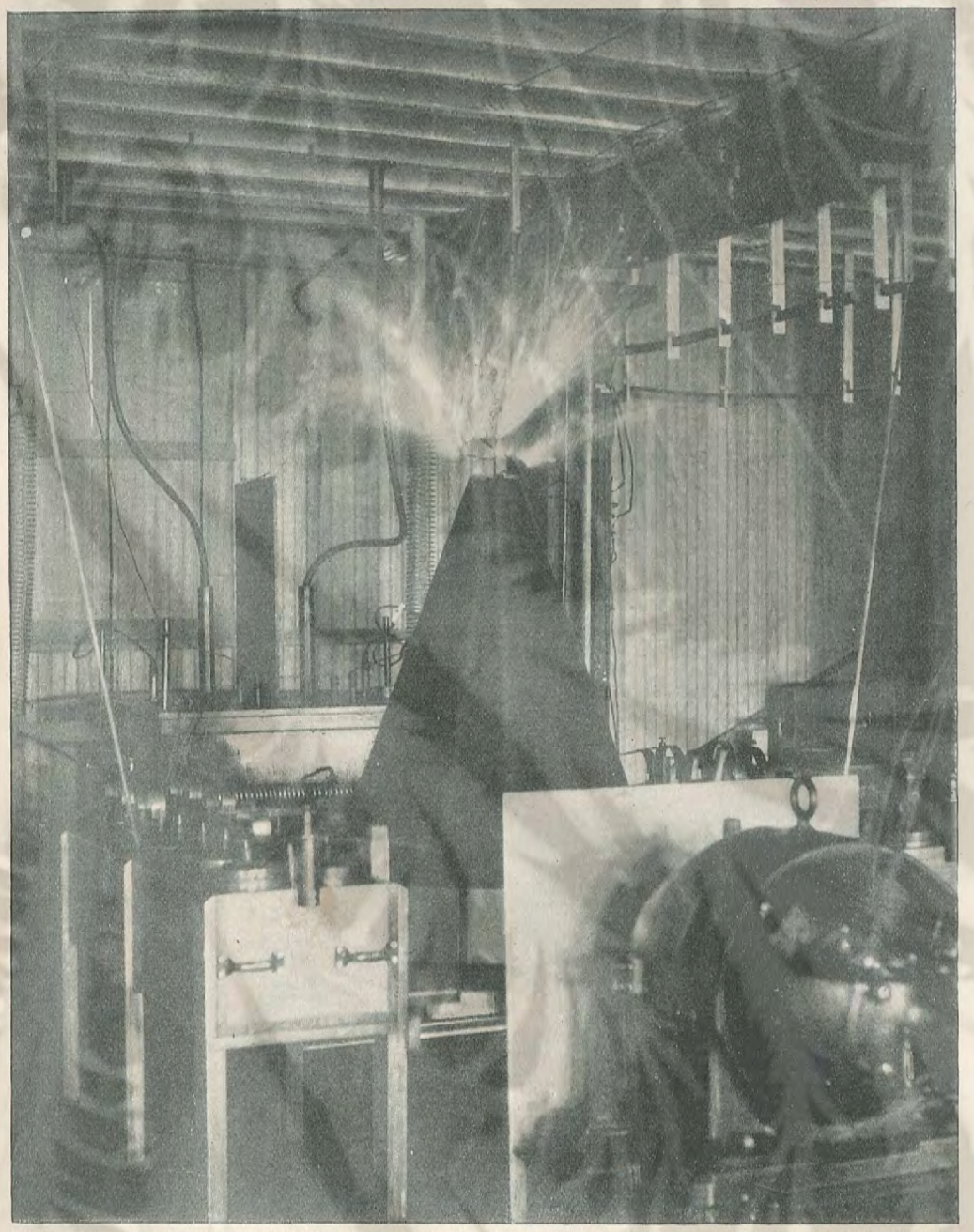


FIG. 15. TESLA COIL FOR ASCERTAINING AND DISCHARGING THE ELECTRICITY OF THE EARTH. THE STREAMERS AT TOP OF COIL ARE OF PURPLE HUE, AND IN FORM RESEMBLE FILAMENTS OF SEAWEED, THE EFFECT OF MASS BEING CAUSED BY PROLONGED EXPOSURE OF FLASH-LIGHT NEGATIVE.

is, to say the least, curious, and deeply suggestive. Mr. Tesla's temerity in trying the effect first upon his own person can be justified only by his close and accurate calculation of what the amount of the discharge from the earth would be.

Considering that in the adjustments necessary here, a small length of wire or a small body of any kind added to the coil or brought into its vicinity may destroy entirely all effect, one can imagine the pleasure which the investigator feels when thus rewarded by unique phenomena. After searching with patient toil for two or three years after a result calculated in advance, he is compensated by being able to wit-

ness a most magnificent display of fiery streams and lightning discharges breaking out from the tip of the wire with the roar of a gas-well. Aside from their deep scientific import and their wondrous fascination as a spectacle, such effects point to many new realizations making for the higher welfare of the human race. The transmission of power and intelligence is but one thing; the modification of climatic conditions may be another. Perchance we shall "call up" Mars in this way some day, the electrical charge of both planets being utilized in signals.

Here are great results, lofty aims, and noble ideas; and yet they are but a beggarly few of all those with which Mr. Tesla, by his simple, modest work, has associated his name during recent years. He is not an impracticable visionary, but a worker who, with solid achievements behind him, seeks larger and better ones that lie before, as well as fuller knowledge. I have ventured to supplement data as to his late inventions by some of his views as to the ether, which throughout this presentation of his work has been treated familiarly as the maid-of-all-work of the universe. All our explanations of things are but half-way houses to the ultimate facts. It may be said, then, in conclusion, that while Mr. Tesla does not hold Professor Oliver Lodge's ingenious but intricate notion of two electricities and two ethers, and of the ether as itself electricity, he does belong to what Lord Kelvin has spoken of as the nineteenth-century school of plenum, accepting one ether for light, heat, electricity, and magnetism, outward manifestations of an inward unity whose secret we shall some day learn.

Thomas Commerford Martin.

IN TESLA'S LABORATORY.

HERE in the dark what ghostly figures press!—
No phantom of the Past, or grim or sad;
No wailing spirit of woe; no specter, clad
In white and wandering cloud, whose dumb distress
Is that its crime it never may confess;
No shape from the strewn sea; nor they that add
The link of Life and Death—the tearless mad,
That live nor die in dreary nothingness:

But blessèd spirits waiting to be born—
Thoughts, to unlock the fettering chains of Things;
The Better Time; the Universal Good.
Their smile is like the joyous break of morn;
How fair, how near, how wistfully they brood!
Listen! that murmur is of angels' wings.

Robert Underwood Johnson.

OLD DUTCH MASTERS.

FERDINAND BOL (1616–1680).

FERDINAND BOL was the oldest student in Rembrandt's house in Amsterdam. He was one of the first, and by many is considered to have been the best. Very little is known of his life. He was born at Dort, in June, 1616, and became a pupil of Rembrandt toward 1630, when about fourteen years of age, and is not known to have had any other instructor. In 1652 he became a citizen of Amsterdam, and died there, on July 24, 1680, a rich man. Bol is considered chiefly as a portrait-painter, though he executed many historical works, and his etchings are highly esteemed. In his early pictures he adheres to the manner of his master, as may be readily observed in his portrait of Saskia, Rembrandt's wife, in the Brussels Museum, and in other of his works prior to 1642, in which he comes very near his master. After this he endeavors to strike out for himself, becomes different from Rembrandt in every way, and does not succeed very well, until finally we have a mas-



ENGRAVED BY T. OOLE.

PORTRAIT OF A MAN. BY FERDINAND BOL.

LIGHT

AND OTHER

HIGH FREQUENCY PHENOMENA.

BY

NIKOLA TESLA.

A LECTURE DELIVERED BEFORE THE NATIONAL ELECTRIC LIGHT ASSOCIATION AT ITS

SIXTEENTH CONVENTION,

HELD AT

ST. LOUIS, MO.,

February 28th, March 1st and 2d, 1893

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Introductory—Some Thoughts on the Eye.

When we look at the world around us, on nature, we are impressed with its beauty and grandeur. Each thing we perceive, though it may be vanishingly small, is in itself a world, that is, like the whole of the visible universe, matter and force governed by law—a world, the contemplation of which fills us with feelings of wonder and irresistibly urges us to ceaseless thought and inquiry. But in all this vast world, of all objects our senses reveal to us, the most marvelous, the most appealing to our imagination, appears, no doubt, a highly developed organism, a thinking being. If there is anything fitted to make us admire nature's handiwork, it is certainly this inconceivable structure, which performs its innumerable motions in obedience to external influence. To understand its workings, to get a deeper insight into this nature's masterpiece, has ever been for thinkers a fascinating aim, and after many centuries of arduous research men have arrived at a fair understanding of the functions of its organs and senses. Again, in all the perfect harmony of its parts, of the parts which constitute the material or tangible of our being, of all its organs and senses, the eye is the most wonderful. It is the most precious, the most indispensable of our receptive or directive organs; it is the great gateway through which all

knowledge enters the mind. Of all our organs, it is the one which is in the most intimate relation with that which we call intellect. So intimate is this relation, that it is often said that the very soul shows itself in the eye.

It can be taken as a fact, which the theory of the action of the eye implies, that for each external impression, that is, for each image produced upon the retina, the ends of the visual nerves, concerned in the conveyance of the impression to the mind, must be under a peculiar stress or in a vibratory state. It now does not seem improbable that, when by the power of thought an image is evoked, a distinct reflex action, no matter how weak, is exerted upon certain ends of the visual nerves, and therefore upon the retina. Will it ever be within human power to analyze the condition of the retina, when disturbed by thought or reflex action, by the help of some optical or other means of such sensitiveness that a clear idea of its state might be gained at any time? If this were possible, then the problem of reading one's thoughts with precision, like the characters of an open book, might be much easier to solve than many problems belonging to the domain of positive physical science, in the solution of which many, if not the majority, of scientific men implicitly believe. Helmholtz has shown that the fundi of the eyes are themselves luminous, and he was able to *see* in total darkness the movement of his arm by the light of his own eyes. This is one of the most remarkable experiments recorded in the history of science, and probably only a few men could satisfactorily repeat it, for it is very likely that the luminosity of the eyes is associated with uncommon activity of the brain and great imaginative power. It is fluorescence of brain action, as it were.

Another fact having a bearing on this subject, which has probably been noted by many, since it is stated in popular expressions, but which I cannot recollect to have found chronicled as a positive result of observation, is that at times, when a sudden idea or image presents itself to the intellect, there is a distinct and sometimes painful sensation of luminosity produced in the eye, observable even in broad daylight.

The saying, then, that the soul shows itself in the eye, is deeply founded, and we feel that it expresses a great truth. It has a profound meaning even for one who, like a poet or artist, only following his inborn instinct or love for nature, finds delight in aimless thoughts and in the mere contemplation of natural phenomena, but a still more profound meaning for one who, in the spirit of positive scientific investigation, seeks to ascertain the causes of the effects. It is principally the natural philosopher, the physicist, for whom the eye is the subject of the most intense admiration.

Two facts about the eye must forcibly impress the mind of the physicist, notwithstanding he may think or say that it is an imperfect optical instrument, forgetting that the very conception of that which is perfect, or seems so to him, has been gained through this same instrument. Firstly, the eye is, as far as our positive knowledge goes, the only organ which is *directly* affected by that subtile medium which, as science teaches us, must fill all space; secondly, it is the most sensitive of our organs, incomparably more sensitive to external impressions than any other.

The organ of hearing implies the impact of ponderable bodies, the organ of smell the transference of detached material particles, and the organs of taste, and of touch or force, the direct contact, or at least some interference of ponderable matter; and this is true even in those

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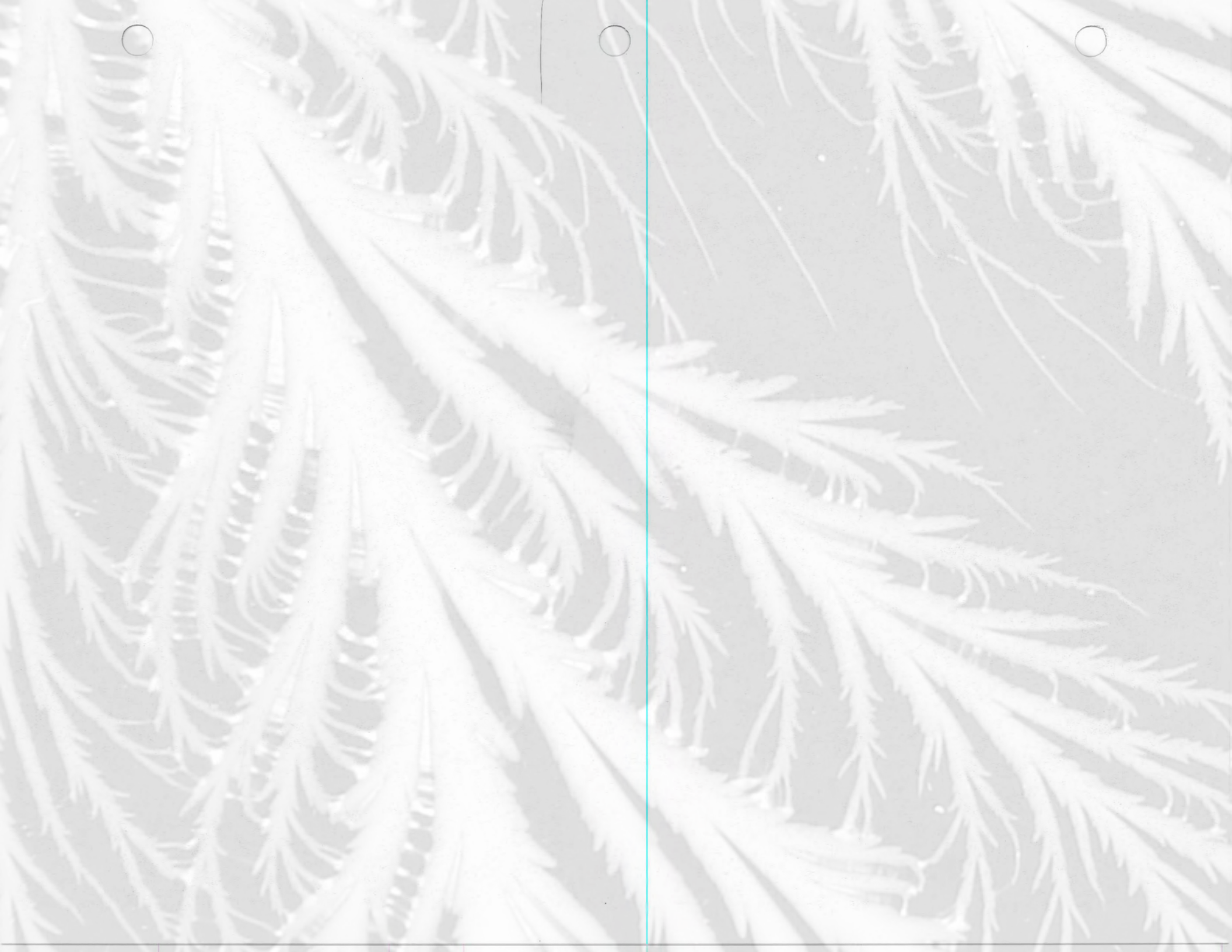
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Two facts about the eye must forcibly impress the mind of the physicist, notwithstanding he may think or say that it is an imperfect optical instrument, forgetting that the very conception of that which is perfect, or seems so to him, has been gained through this same instrument. Firstly, the eye is, as far as our positive knowledge goes, the only organ which is *directly* affected by that subtile medium which, as science teaches us, must fill all space; secondly, it is the most sensitive of our organs, incomparably more sensitive to external impressions than any other.

The organ of hearing implies the impact of ponderable bodies, the organ of smell the transference of detached material particles, and the organs of taste, and of touch or force, the direct contact, or at least some interference of ponderable matter; and this is true even in those

instances of animal organisms in which some of these organs are developed to a degree of truly marvelous perfection. This being so, it seems wonderful that the organ of sight solely should be capable of being stirred by that which all our other organs are powerless to detect, which yet plays an essential part in all natural phenomena, which transmits all energy and sustains all motion and, that most intricate of all, life, but which has properties such that even a scientifically trained mind cannot help drawing a distinction between it and all that is called matter. Considering merely this, and the fact that the eye, by its marvelous power, widens our otherwise very narrow range of perception far beyond the limits of the small world, which is our own, to embrace myriads of other worlds, suns and stars in the infinite depths of the universe, would make it justifiable to assert that it is an organ of a higher order. Its performances are beyond comprehension. Nature, so far as we know, never produced anything more wonderful. We can get barely a faint idea of its prodigious power by analyzing what it does and by comparing. When ether waves impinge upon the human body, they produce the sensations of warmth or cold, pleasure or pain, or perhaps other sensations of which we are not aware, and any degree or intensity of these sensations; which degrees are infinite in number, hence an infinite number of distinct sensations. But our sense of touch, or our sense of force, cannot reveal to us these differences in degree or intensity unless they are very great. Now, we can readily conceive how an organism, such as the human in the eternal process of evolution, or, more philosophically speaking, adaptation to nature, being constrained to the use of only the sense of touch or force, for instance, might develop this sense to such a degree of sensitiveness or perfection that it

would be capable of distinguishing the minutest differences in the temperature of a body even at some distance, to a hundredth, or thousandth, or millionth part of a degree. Yet, even this apparently impossible performance would not begin to compare with that of the eye, which is capable of distinguishing and conveying to the mind in a single instant innumerable peculiarities of the body, be it in form or color or other respects. This power of the eye rests upon two things, namely, the rectilinear propagation of the disturbance by which it is affected, and upon its sensitiveness. To say that the eye is sensitive is not saying anything. Compared with it, all other organs are monstrously crude. The organ of smell which guides a dog on the trail of a deer, the organ of touch or force which guides an insect in its wanderings, the organ of hearing, which is affected by the slightest disturbances of the air, are sensitive organs, to be sure, but what are they compared with the human eye! No doubt it responds to the faintest echoes or reverberations of the medium; no doubt, it brings us tidings from other worlds, infinitely remote, but in a language we cannot as yet always understand. And why not? Because we live in a medium filled with air and other gases, vapors and a dense mass of solid particles flying about. These play an important part in many phenomena; they fritter away the energy of the vibrations before they can reach the eye; they, too, are the carriers of germs of destruction; they get into our lungs and other organs, clog up the channels and imperceptibly, yet inevitably, arrest the stream of life. Could we but do away with all ponderable matter in the line of sight of the telescope, it would reveal to us undreamt of marvels. Even the unaided eye, I think, would be capable of distinguishing in the pure medium small

objects at distances measured probably by hundreds or, perhaps, thousands of miles.

But there is something else about the eye which impresses us still more than these wonderful features which we observe, viewing it from the standpoint of a physicist, merely as an optical instrument—something which appeals to us more than its marvelous faculty of being directly affected by the vibrations of the medium, without interference of gross matter, and more than its inconceivable sensitiveness and discerning power. It is its significance in the processes of life. No matter what one's views on Nature and life may be, he must stand amazed when, for the first time in his thoughts, he realizes the importance of the eye in the physical processes and mental performances of the human organism. And how could it be otherwise, when he realizes that the eye is the means through which the human race has acquired the entire knowledge it possesses, that it controls all our motions; more, still, all our actions.

There is no way of acquiring knowledge except through the eye. What is the foundation of all philosophical systems of ancient and modern times, in fact, of all the philosophy of man? *I am, I think; I think, therefore, I am.* But how could I think, and how would I know that I exist if I had not the eye? For knowledge involves consciousness; consciousness involves ideas, conceptions; conceptions involve pictures or images, and images, the sense of vision, and, therefore, the organ of sight. But how about blind men, will be asked? Yes, a blind man may depict in magnificent poems forms and scenes from real life, from a world he physically does not see. A blind man may touch the keys of an instrument with unerring precision, may build the fastest boat, may discover and invent, calculate and construct, may do still greater wonders;

but all the blind men who have done such things have descended from those who had seeing eyes. Nature may reach the same result in many ways. Like a wave in the physical world, in the infinite ocean of the medium which pervades all, so in the world of organisms, in life, an impulse started proceeds onward; at times, may be, with the speed of light, at times, again, so slowly that for ages and ages it seems to stay, passing through processes of a complexity inconceivable to men, but in all its forms, in all its stages, its energy ever and ever integrally present. A single ray of light from a distant star falling upon the eye of a tyrant in bygone times may have altered the course of his life, may have changed the destiny of nations, may have transformed the surface of the globe, so intricate, so inconceivably complex are the processes in Nature. In no way can we get such an overwhelming idea of the grandeur of Nature as when we consider that in accordance with the law of the conservation of energy, throughout the Infinite, the forces are in a perfect balance, and hence the energy of a single thought may determine the motion of a Universe. It is not necessary that every individual, not even that every generation or many generations, should have the physical instrument of sight, in order to be able to form images and to think, that is, form ideas or conceptions; but some time or other, during the process of evolution, the eye certainly must have existed, else thought, as we understand it, would be impossible; else conceptions, life, spirit, intellect, mind, call it as you may, could not exist. It is conceivable that in some other world, in some other beings, the eye is replaced by a different organ, equally or more perfect, but these beings cannot be men.

Now, what prompts us to all voluntary motions and actions of any kind? Again, the eye. If I am con-

scious of the motion, I must have an idea or conception—that is, an image—therefore, the eye. If I am not precisely conscious of the motion, it is because the images are vague or indistinct, being blurred by the superimposition of many. But when I perform the motion, does the impulse which prompts me to the action come from within or from without? The greatest physicists have not disdained to endeavor to answer this and similar questions, and have at times abandoned themselves to the delights of pure and unrestrained thought. Such questions are generally considered not to belong to the realm of positive physical science, but will before long be annexed to its domain. Helmholtz has probably thought more on life than any modern scientist. Lord Kelvin expressed his belief that life's process is electrical, and that there is a force inherent to the organism and determining its motions. Just as much as I am convined of any physical truth I am convinced that the motive impulse must come from the outside; for, consider the lowest organism we know—and there are probably many lower ones—an aggregation of a few cells only. If it is capable of voluntary motion, it can perform an infinite number of motions, all definite and precise. But now a mechanism consisting of a finite number of parts, and few at that, cannot perform an infinite number of definite motions; hence, the impulses which govern its movements must come from the environment. So the atom, the ulterior element of the Universe's structure, is tossed about in space eternally, a play to external influences, like a float in a troubled sea. Were it to stop its motion, *it would die*. Matter at rest, if such a thing could exist, would be matter dead. Death of matter! Never has a sentence of deeper philosphical meaning been uttered. This is the way in which Professor Dewar forcibly

expresses it in the description of his admirable experiments, in which liquid oxygen is handled as one handles water, and air at ordinary pressure is made to condense and even to solidify by the intense cold—experiments which serve to illustrate, in his language, the last feeble manifestations of life, the last quiverings of matter about to die. But human eyes shall not witness such death. There is no death of matter, for throughout the infinite universe all has to move, to vibrate—that is, to live.

I have made the preceding statements at the peril of treading upon metaphysical ground in my desire to introduce the subject of this lecture in a manner not altogether uninteresting, I may hope, to an audience such as I have the honor to address. But now, then, returning to the subject, this divine organ of sight, this indispensable instrument for thought and all intellectual enjoyment, which lays open to us the marvels of this Universe, through which we have acquired what knowledge we possess, and which prompts us to and controls all our physical and mental activity—by what is it affected? By light! What is light?

We have witnessed the great strides which have been made in all departments of science in recent years. So great have been the advances that we cannot refrain from asking ourselves, Is this all true, or is it but a dream? Centuries ago men have lived, have thought, discovered, invented, and have believed that they were soaring, while they were merely proceeding at a snail's pace. So we, too, may be mistaken. But, taking the truth of the observed events as one of the implied facts of science, we must rejoice in the immense progress already made, and still more in the anticipation of what must come, judging from the possibilities opened up by modern research. There is, however, an advance which

we have been witnessing, which must be particularly gratifying to every lover of progress. It is not a discovery, or an invention, or an achievement in any particular direction. It is an advance in all directions of scientific thought and experiment. I mean the generalization of the natural forces and phenomena, the looming up of a certain broad idea on the scientific horizon. It is this idea which has, however, long ago taken possession of the most advanced minds, to which I desire to call your attention, and which I intend to illustrate, in a general way, in these experiments, as the first step in answering the question, "What is light?" and to realize the modern meaning of this word.

It is beyond the scope of my lecture to dwell upon the subject of light in general, my object being merely to bring presently to your notice a certain class of light effects and a number of phenomena observed in pursuing the study of these effects. But to be consistent in my remarks it is necessary to state that according to that idea, now accepted by the majority of scientific men as a positive result of theoretical and experimental investigation, the various forms or manifestations of energy which were generally designated as "electric" or, more precisely, "electromagnetic," are energy manifestations of the same nature as those of radiant heat and light. Therefore, the phenomena of light and heat, and others besides these, may be called electrical phenomena. Thus electrical science has become the mother science of all, and its study has become all important. The day when we shall know exactly what "electricity" is, will chronicle an event probably greater, more important, than any other recorded in the history of the human race. The time will come when the comfort, the very existence, perhaps, of man will depend upon that wonderful agent. For our existence and comfort we

require heat, light and mechanical power. How do we now get all these? We get them from fuel; we get them by consuming material. What will man do when the forests disappear, when the coal fields are exhausted? Only one thing, according to our present knowledge, will remain; that is, to transmit power at great distances. Men will go to the waterfalls, to the tides, which are the stores of an infinitesimal part of Nature's immeasurable energy. There will they harness the energy and transmit the same to their settlements, to warm their homes by, to give them light, and to keep their obedient slaves, the machines, toiling. But how will they transmit this energy if not by electricity? Judge, then, if the comfort, nay, the very existence, of man will not depend on electricity. I am aware that this view is not that of a practical engineer; but neither is it that of an illusionist, for it is certain that power transmission, which, at present, is merely a stimulus to enterprise, will some day be a dire necessity.

It is more important for the student who takes up the study of light phenomena to make himself thoroughly acquainted with certain modern views than to peruse entire books on the subject of light itself, as disconnected from these views. Were I, therefore, to make these demonstrations before students seeking information—and for the sake of the few of those who may be present, give me leave to so assume—it would be my principal endeavor to impress these views upon their minds in this series of experiments.

It might be sufficient for this purpose to perform a simple and well-known experiment. I might take a familiar appliance, a Leyden jar, charge it from a frictional machine, and then discharge it. In explaining to you its permanent state when charged, and its transitory condition when discharging; calling your

attention to the forces which enter into play and to the various phenomena they produce, and pointing out the relation of the forces and phenomena, I might fully succeed in illustrating that modern idea. To the thinker, no doubt, this simple experiment would appeal as much as the most magnificent display. But this is to be an experimental demonstration, and one which should possess besides instructive, also entertaining features, and as such, a simple experiment, such as the one cited, would not go very far towards the attainment of the lecturer's aim. I must, therefore, choose another way of illustrating, more spectacular certainly, but perhaps also more instructive. Instead of the frictional machine and Leyden jar, I shall avail myself in these experiments of an induction coil of peculiar properties, which was described in detail by me in a lecture before the London Institution of Electrical Engineers, in February, 1892. This induction coil is capable of yielding currents of enormous potential differences, alternating with extreme rapidity. With this apparatus I shall endeavor to show you three distinct classes of effects, or phenomena, and it is my desire that each experiment, while serving for the purposes of illustration, shall at the same time teach us some novel truth, or show us some novel aspect of this fascinating science. But before doing this, it seems proper and useful to dwell upon the apparatus employed and method of obtaining the high potentials and high frequency currents which are made use of in these experiments.

ON THE APPARATUS AND METHOD OF CONVERSION.

These high-frequency currents are obtained in a peculiar manner. The method employed was advanced by me about two years ago in an experimental lecture

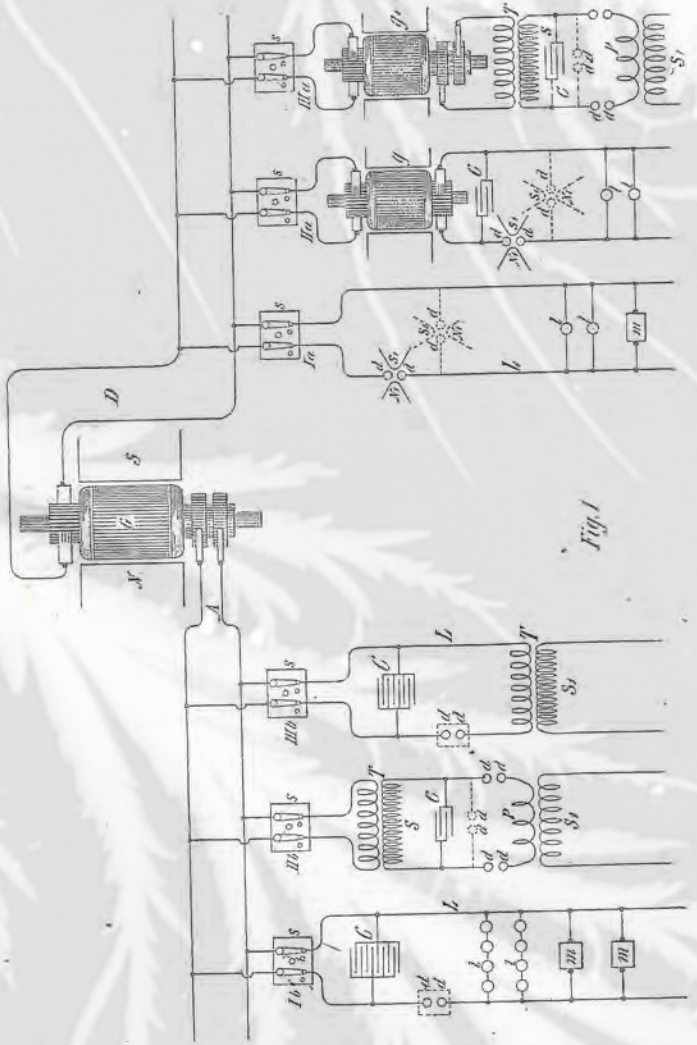


FIG. 1.—PLAN OF CONNECTIONS USED IN THE CONVERSION BY MEANS OF THE DISRUPTIVE ARC DISCHARGE.

before the American Institute of Electrical Engineers. A number of ways, as practiced in the laboratory, of obtaining these currents, either from continuous or low-frequency alternating currents, is diagrammatically indicated in Fig. 1, which will be later described in detail. The general plan is to charge condensers, from a direct or alternate current source, preferably of high tension, and to discharge them disruptively while observing well-known conditions necessary to maintain the oscillations of the current. In view of the general interest taken in high-frequency currents and effects producible by them, it seems to me advisable to dwell at some length upon this method of conversion. In order to give you a clear idea of the action, I will suppose that a continuous current generator is employed, which is often very convenient. It is desirable that the generator should possess such high tension as to be able to break through a small air space. If this is not the case, then auxiliary means have to be resorted to, some of which will be indicated subsequently. When the condensers are charged to a certain potential, the air or insulating space gives way and a disruptive discharge occurs. There is then a sudden rush of current, and generally a large portion of the accumulated electrical energy spends itself. The condensers are thereupon quickly charged, and the same process is repeated in more or less rapid succession. To produce such sudden rushes of current it is necessary to observe certain conditions. If the rate at which the condensers are discharged is the same as that at which they are charged, then, clearly, in the assumed case the condensers do not come into play. If the rate of discharge be smaller than the rate of charging, then, again, the condensers cannot play an important part. But if, on the contrary, the rate of discharging is greater than that of charging, then a succession of rushes of current

is obtained. It is evident that if the rate at which the energy is being dissipated by the discharge is very much greater than the rate of supply to the condensers, the sudden rushes will be comparatively few, with long time intervals between. This always occurs when a condenser of considerable capacity is charged by means of a comparatively small machine. If the rates of supply and dissipation are not widely different, then the rushes of current will be in quicker succession, and this the more, the more nearly equal both the rates are, until natural limitations incident to each case, and depending upon a number of causes, are reached. Thus we are able to obtain from a continuous current generator as rapid a succession of discharges as we like. Of course, the higher the tension of the generator, the smaller need be the capacity of the condensers, and for this reason, principally, it is of advantage to employ a generator of very high tension. Besides, such a generator permits the attaining of greater rates of vibration.

The rushes of current may be of the same direction under the conditions before assumed, but most generally there is an oscillation superimposed upon the fundamental vibration of the current. When the conditions are so determined that there is no oscillation, the current impulses are unidirectional and thus a means is provided of transforming a continuous current of high tension into a direct current of lower tension, which I think may find employment in the arts.

This method of conversion is exceedingly interesting and I was much impressed by its beauty when I first conceived it. It is ideal in certain respects. It involves the employment of no mechanical devices of any kind, and it allows of obtaining currents of any desired frequency from an ordinary circuit, direct or alternating. The frequency of the fundamental dis-

charges depending on the relative rates of supply and dissipation can be readily varied within wide limits by simple adjustments of these quantities, and the frequency of the superimposed vibration by the determination of the capacity, self-induction and resistance of the circuit. The potential of the currents, again, may be raised as high as any insulation is capable of withstanding safely, by combining capacity and self-induction or by induction in a secondary, which need have but comparatively few turns.

As the conditions are often such that the intermittence or oscillation does not readily establish itself, especially when a direct current source is employed, it is of advantage to associate an interrupter with the arc, and I have, some time ago, indicated the use of an air-blast or magnet, or other such device readily at hand. The magnet is employed with special advantage in the conversion of direct currents, as it is then very effective. If the primary source is an alternate current generator, it is desirable, as I have stated on another occasion, that the frequency should be low, and that the currents forming the arc be large, in order to render the magnet more effective.

A form of such discharger, with a magnet, which has been found convenient, and adopted, after some trials, in the conversion of direct currents particularly, is illustrated in Fig. 2. N S are the pole-pieces of a very strong magnet, which is excited by a coil, C. The pole-pieces are slotted for adjustment, and can be fastened in any position by screws, s_1 s_1. The discharge rods d d_1, thinned down on the ends, in order to allow a closer approach of the magnetic pole-pieces, pass through the columns of brass b b_1, and are fastened in position by screws, s_2 s_2. Springs, r r_1, and collars, c c_1, are slipped on the rods, the latter serving to set the points of the

rods at a certain suitable distance by means of screws, s_3 s_3, and the former to draw the points apart. When it is desired to start the arc one of the hard rubber handles h h_1 is tapped quickly with the hand, whereby the points of the rods are brought in contact, but are instantly separated by the springs r r_1. Such an arrangement has been found to be often necessary, namely, in

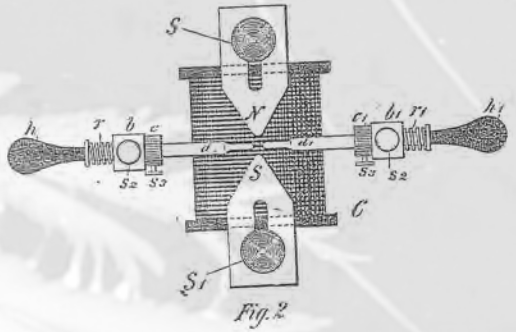


FIG. 2.—FORM OF DISCHARGER WITH MAGNET USED IN THE DIRECT CURRENT CONVERSION.

cases when the electromotive force was not large enough to cause the discharge to break through the gap, and also when it was desirable to avoid short-circuiting of the generator by the metallic contact of the rods. The rapidity of the interruptions of the current with a magnet depends on the intensity of the magnetic field and on the potential difference at the ends of the arc. The interruptions are generally in such quick succession as to produce a musical sound. Years ago it was observed

that when a powerful induction coil was discharged between the poles of a strong magnet the discharge produced a loud noise not unlike a small pistol shot. It was vaguely stated that the spark was intensified by the presence of the magnetic field. It is now clear that the discharge current, flowing for some time, was interrupted a great number of times by the magnet, thus producing the sound. The phenomenon is especially marked when the field circuit of a large magnet or dynamo is broken in a powerful magnetic field.

When the current through the gap is comparatively large, it is of advantage to slip on the points of the discharge rods pieces of very hard carbon, and let the arc play between the carbon pieces. This preserves the rods, and, besides, has the advantage of keeping the air space hotter, as the heat is not conducted away as quickly through the carbons, and the result is that a smaller electromotive force in the arc gap is required to maintain a succession of discharges.

Another form of discharger which may be employed with advantage in some cases is illustrated in Fig. 3. In this form the discharge rods $d\,d_1$ pass through perforations in a wooden box B, which is thickly coated with mica on the inside, as indicated by the heavy lines. The perforations are provided with mica tubes $m\,m_1$ of some thickness, which are preferably not in contact with the rods $d\,d_1$. The box has a cover C, which is a little larger, and descends on the outside of the box. The spark gap is warmed by a small lamp l, contained in the box. A plate p above the lamp allows the draught to pass only through the chimney c of the lamp, the air entering through holes $o\,o$ in or near the bottom of the box and following the path indicated by the arrows. When the discharger is in operation the door of the box is closed so that the light of the arc is not visible outside. It is desirable to exclude the light as perfectly as possible, as it interferes with some experiments. This form of discharger is simple and very effective when properly manipulated. The air being warmed to a certain temperature has its insulating power impaired, it becomes dielectrically weak, as it were, and the consequence is that the arc can be established at much greater

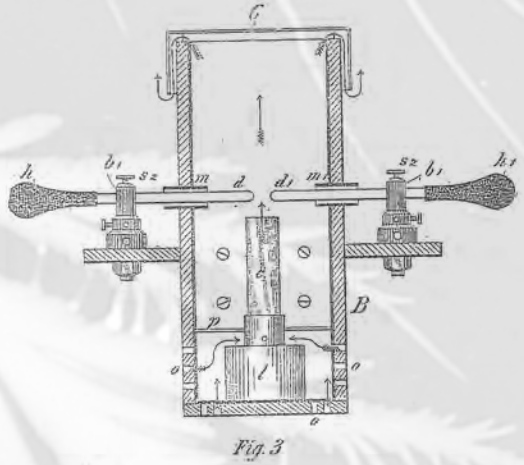


Fig. 3

FIG. 8.—DISCHARGES WITH HOT AIR DRAFT.

distance. The air should, of course, be sufficiently insulating to allow the discharge to pass through the gap *disruptively*. The arc formed under such conditions, when long, may be made extremely sensitive, and the weak draught through the lamp chimney c is quite sufficient to produce rapid interruptions. The adjustment is made by regulating the temperature and velocity of

the draught. Instead of using a lamp, it answers the purpose to provide for a draught of warm air in other ways. A very simple way which has been practiced is to inclose the arc in a long vertical tube, with plates on the top and bottom for regulating the temperature and velocity of the air current. Some provision had to be made for deadening the sound.

The air may also be rendered dielectrically weak by rarefaction. Dischargers of this kind have likewise been used by me in connection with the magnet. A large tube is for this purpose provided with heavy electrodes of carbon or metal, between which the discharge is made to pass, the tube being placed in a powerful magnetic field. The exhaustion of the tube is carried to a point at which the discharge breaks through easily, but the pressure should be more than seventy-five millimeters, at which the ordinary thread discharge occurs. In another form of discharger, combining the features before mentioned, the discharge was made to pass between two adjustable magnetic pole pieces, the space between them being kept at an elevated temperature.

It should be remarked here, that when such, or interrupting devices of any kind, are used and the currents are passed through the primary of a disruptive discharge coil, it is not, as a rule, of advantage to produce a number of interruptions of the current per second greater than the natural frequency of vibration of the dynamo supply circuit, which is ordinarily small. It should also be pointed out here that while the devices mentioned in connection with the disruptive discharge are advantageous under certain conditions, they may be sometimes a source of trouble, as they produce intermittences and other irregularities in the vibration, which it would be very desirable to overcome.

There is, I regret to say, in this beautiful method of

conversion, a defect, which fortunately is not vital, and which I have been gradually overcoming. I will best call attention to this defect, and indicate a fruitful line of work, by comparing the electrical process with its mechanical analogue. The process may be illustrated in this manner: Imagine a tank with a wide opening at the bottom, which is kept closed by spring pressure, but so that it snaps off *suddenly* when the liquid in the tank has reached a certain height. Let the liquid be supplied to the tank by means of a pipe, feeding at a certain rate. When the critical height of the liquid is reached, the spring gives way and the bottom of the tank drops out. Instantly the liquid falls through the wide opening, and the spring, reasserting itself, closes the bottom again. The tank is now filled, and after a certain time interval the same process is repeated. It is clear that if the pipe feeds the liquid quicker than the bottom outlet is capable of letting it pass through, the bottom will remain off, and the tank will still overflow. If the rates of supply are exactly equal, then the bottom lid will remain partially open, and no vibration of the same and of the liquid column will generally occur, though it might, if started by some means. But if the inlet pipe does not feed the liquid fast enough for the outlet, then there will be always vibration. Again, in such case, each time the bottom flaps up or down, the spring and the liquid column, if the pliability of the spring and the inertia of the moving parts are properly chosen, will perform independent vibrations. In this analogue the liquid may be likened to electricity or electrical energy, the tank to the condenser, the spring to the dielectric and the pipe to the conductor through which electricity is supplied to the condenser. To make this analogy quite complete it is necessary to make the assumption that the bottom, each time it gives way, is knocked violently against a

non-elastic stop, this impact involving some loss of energy, and that, besides, some dissipation of energy results, due to frictional losses. In the preceding analogue the liquid is supposed to be under a steady pressure. If the pressure of the liquid be assumed to vary rhythmically, this may be taken as corresponding to the case of an alternating current. The process is then not quite as simple to consider, but the action is the same in principle.

It is desirable, in order to maintain the vibration economically, to reduce the impact and frictional losses as much as possible. As regards the latter, which in the electrical analogue correspond to the losses due to the resistance of the circuits, it is impossible to obviate them entirely, but they can be reduced to a minimum by a proper selection of the dimensions of the circuits and by the employment of thin conductors in the form of strands. But the loss of energy caused by the first breaking through of the dielectric—which in the above example corresponds to the violent knock of the bottom against the inelastic stop—would be more important to overcome. At the moment of the breaking through, the air space has a very high resistance, which is probably reduced to a very small value when the current has reached some strength, and the space is brought to a high temperature. It would materially diminish the loss of energy if the space were always kept at an extremely high temperature, but then there would be no disruptive break. By warming the space moderately by means of a lamp or otherwise, the economy, as far as the arc is concerned, is sensibly increased. But the magnet or other interrupting device does not diminish the loss in the arc. Likewise, a jet of air only facilitates the carrying off of the energy. Air, or a gas in general, behaves curiously in this respect. When two

bodies, charged to a very high potential, discharge disruptively through an air space, any amount of energy may be carried off by the air. This energy is evidently dissipated by bodily carriers, in impact and collisional losses of the molecules. The exchange of the molecules in the space occurs with inconceivable rapidity. A powerful discharge taking place between two electrodes, they may remain entirely cool, and yet the loss in the air may represent any amount of energy. It is perfectly practicable, with very great potential differences in the gap, to dissipate several horse power in the arc of the discharge without even noticing a small increase in the temperature of the electrodes. All the frictional losses occur then practically in the air. If the exchange of the air molecules is prevented, as by enclosing the air hermetically, the gas inside of the vessel is brought quickly to a high temperature, even with a very small discharge. It is difficult to estimate how much of the energy is lost in sound waves, audible or not, in a powerful discharge. When the currents through the gap are large, the electrodes may become rapidly heated; but this is not a reliable measure of the energy wasted in the arc, as the loss through the gap itself may be comparatively small. The air or a gas in general is, at ordinary pressures, at least, clearly not the best medium through which a disruptive discharge should occur. Air or other gas under great pressure is, of course, a much more suitable medium for the discharge gap. I have carried on long-continued experiments in this direction, unfortunately less practicable on account of the difficulties and expense in getting air under great pressure. But even if the medium in the discharge space is solid or liquid, still the same losses take place, though they are generally smaller, for just as soon as the arc is established, the solid or liquid is

volatilized. Indeed, there is no body known which would not be disintegrated by the arc, and it is an open question among scientific men whether an arc discharge could occur at all in the air itself without the particles of the electrodes being torn off. When the current through the gap is very small and the arc very long, I believe that a relatively considerable amount of heat is taken up in the disintegration of the electrodes, which partially on this account may remain quite cold.

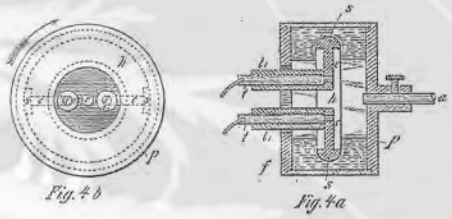
The ideal medium for a discharge gap should only *crack*, and the ideal electrode should be of some material which cannot be disintegrated. With small currents through the gap it is best to employ aluminum, but not when the currents are large. The disruptive break in the air, or, more or less, in any ordinary medium, is not of the nature of a crack, but is rather comparable to the piercing of innumerable bullets through a mass offering great frictional resistance to the motion of the bullets, thus involving considerable loss of energy. A medium which would merely crack when strained electrostatically, and this possibly might be the case with a perfect vacuum—that is, pure ether—would involve a very small loss in the gap, so small as to be entirely negligible, at least theoretically, because a crack may be produced by an infinitely small displacement. In exhausting an oblong bulb provided with two aluminum terminals, with the greatest care I have succeeded in producing such a vacuum that the secondary discharge of a disruptive discharge coil would break disruptively through the bulb in the form of fine spark streams. The curious point was that the discharge would completely ignore the terminals and start far behind the two aluminum plates which served as electrodes. This extraordinarily high vacuum could only be maintained for a very short while. To return to the ideal medium. Think, for the

sake of illustration, of a piece of glass or similar body clamped in a vise, and the latter tightened more and more. At a certain point a minute increase of the pressure will cause the glass to crack. The loss of energy involved in splitting the glass may be practically nothing, for, though the force is great, the displacement need be but extremely small. Now, imagine that the glass would possess the property of closing the crack again perfectly upon a minute diminution of the pressure. This is the way the dielectric in the discharge space should behave; but, inasmuch as there would be always some loss in the gap, the medium, which should be continuous, should exchange through the gap at a rapid rate. In the preceding example, the glass being perfectly closed would mean that the dielectric in the discharge space possesses a great insulating power; the glass being cracked would signify that the medium in the space is a good conductor. The dielectric should vary enormously in resistance by minute variations of the electromotive force across the discharge space. This condition is attained, but in an extremely imperfect manner, by warming the air space to a certain critical temperature, dependent on the electromotive force across the gap, or by otherwise impairing the insulating power of the air. But, as a matter of fact, the air never does break down *disruptively*, if this term be rigorously interpreted, for before the sudden rush of the current occurs, there is always a weak current preceding it, which rises first gradually and then with comparative suddenness. That is the reason why the rate of change is very much greater when glass, for instance, is broken than when the break takes place through an air space of equivalent dielectric strength. As a medium for the discharge space, a solid, or even a liquid, would be preferable therefor. It is somewhat difficult to conceive

of a solid body which would possess the property of closing instantly after it has been cracked. But a liquid, especially under great pressure, behaves practically like a solid, while it possesses the property of closing the crack. Hence, it was thought that a liquid insulator might be more suitable as a dielectric than air. Following out this idea, a number of different forms of dischargers, in which a variety of such insulators, sometimes under great pressure, were employed, have been experimented upon. It is thought sufficient to dwell, in a few words, upon one of the forms experimented upon. One of these dischargers is illustrated in Figs. 4*a* and 4*b*.

A hollow metal pulley P (Fig. 4*a*) was fastened upon an arbor *a*, which by suitable means was rotated at a considerable speed. In the inside of the pulley, but disconnected from the same, was supported a thin disc h_1 (which is shown thick for the sake of clearness) of hard rubber, in which there were embedded two metal segments *s s*, with metallic extensions *e e*, into which were screwed conducting terminals *t t*, covered with thick tubes of hard rubber *t t*. The rubber disc *h*, with its metallic segments s s, was finished in a lathe, and its entire surface highly polished, so as to offer the smallest possible frictional resistance to the motion through a fluid. In the hollow of the pulley an insulating liquid, such as a thin oil, was poured so as to reach very nearly to the opening left in the flange *f*, which was screwed tightly on the front side of the pulley. The terminals *t t* were connected to the opposite coatings of a battery of condensers so that the discharge occurred through the liquid. When the pulley was rotated the liquid was forced against the rim of the pulley, and considerable liquid pressure resulted. In this simple way the discharge gap was filled with a medium which behaved practically like a solid, which possessed the quality of closing

instantly upon the occurrence of the break, and which, moreover, was circulating through the gap at a rapid rate. Very powerful effects were produced by dischargers of this kind with liquid interrupters, of which a number of different forms were made. It was found that, as expected, a longer spark for a given length of wire was obtainable in this way than by using air as an interrupting device. Generally the speed, and, therefore, also the liquid pressure, was limited by reason of the liquid friction in the form of discharger described; but the practically obtainable speed was more than sufficient to



FIGS. 4*a*, 4*b*.—FORM OF DISCHARGER WITH LIQUID INTERRUPTER.

produce a number of breaks suitable for the circuits ordinarily used. In some instances the metal pulley P was provided with a few projections inwardly, and a definite number of breaks was then produced, which could be computed from the speed of rotation of the pulley. Experiments were also carried on with liquids of different insulating power, with the view of reducing the loss in the arc. When an insulating liquid is moderately warmed the loss in the arc is diminished.

A point of some importance was noted in experiments with various dischargers of this kind. It was

found, for instance, that whereas the conditions maintained in these forms were favorable for the production of a great spark length, the currents so obtained were not best suited to the production of light effects. Experience undoubtedly has shown that for such purposes a harmonic rise and fall of the potential is preferable. Be it that a solid is rendered incandescent, or phosphorescent, or be it that energy is transmitted by condenser coating through the glass, it is quite certain that a harmonically rising and falling potential produces less destructive action, and that the vacuum is more permanently maintained. This would be easily explained if it were ascertained that the process going on in an exhausted vessel is of an electrolytic nature.

In the diagrammatical sketch, Fig. 1, which has been already referred to, the cases which are most likely to be met with in practice are illustrated. One has at his disposal either direct or alternating currents from a supply station. It is convenient for an experimenter in an isolated laboratory to employ a machine G, such as illustrated, capable of giving both kinds of currents. In such case it is also preferable to use a machine with multiple circuits, as in many experiments it is useful and convenient to have at one's disposal currents of different phases. In the sketch, D represents the direct and A the alternating circuit. In each of these, three branch circuits are shown, all of which are provided with double lines switches *s s s s s s*. Consider first the direct current conversion; 1*a* represents the simplest case. If the electromotive force of the generator is sufficient to break through a small air space, at least when the latter is warmed or otherwise rendered poorly insulating, there is no difficulty in maintaining a vibration with fair economy by judicious adjustment of the capacity, self-induction and resistance of the circuit L containing the

devices *l l m*. The magnet N, S, can be in this case advantageously combined with the air space. The discharger *d d* with the magnet may be placed either way, as indicated by the full or by the dotted lines. The circuit 1*a* with the connections and devices is supposed to possess dimensions such as are suitable for the maintenance of a vibration. But usually the electromotive force on the circuit or branch 1*a* will be something like 100 volts or so, and in this case it is not sufficient to break through the gap. Many different means may be used to remedy this by raising the electromotive force across the gap. The simplest is probably to insert a large self-induction coil in series with the circuit L. When the arc is established, as by the discharger illustrated in Fig. 2, the magnet blows the arc out the instant it is formed. Now, the extra current of the break, being of high electromotive force, breaks through the gap, and a path of low resistance for the dynamo current being again provided, there is a sudden rush of the current from the dynamo upon the weakening or subsidence of the extra current. This process is repeated in rapid succession, and in this manner I have maintained oscillation with as low as 50 volts, or even less, across the gap. But conversion on this plan is not to be recommended on account of the too heavy currents through the gap and consequent heating of the electrodes: besides, the frequencies obtained in this way are low, owing to the high self-induction necessarily associated with the circuit. It is very desirable to have the electromotive force as high as possible; first, in order to increase the economy of the conversion, and, secondly, to obtain high frequencies. The difference of potential in this electric oscillation is, of course, the equivalent of the stretching force in the mechanical vibration of the spring. To obtain very rapid vibration in a circuit of

some inertia a great stretching force or difference of potential is necessary. Incidentally, when the electromotive force is very great, the condenser which is usually employed in connection with the circuit need have but a small capacity, and many other advantages are gained. With a view of raising the electromotive force to a many times greater value than obtainable from ordinary distribution circuits, a rotating transformer *g* is used, as indicated in Fig. 2*a*, or else a separate high potential machine is driven by means of a motor operated from the generator G. The latter plan is, in fact, preferable, as changes are easier made. The connections from the high tension winding are quite similar to those in branch 1*a* with the exception that a condenser C, which should be adjustable, is connected to the high tension circuits. Usually, also, an adjustable self-induction coil in series with the circuit has been employed in these experiments. When the tension of the currents is very high the magnet ordinarily used in connection with the discharger is of comparatively small value, as it is quite easy to adjust the dimensions of the circuit so that oscillation is maintained. The employment of a steady electromotive force in the high frequency conversion affords some advantages over the employment of alternating electromotive force, as the adjustments are much simpler, and the action can be easier controlled. But, unfortunately, one is limited by the obtainable potential difference. The windings also break down easily, in consequence of the sparks which form between the sections of the armature or commutator when a vigorous oscillation takes place. Besides, these transformers are expensive to build. It has been found by experience that it is best to follow the plan illustrated in Fig. 3*a*. In this arrangement a rotating transformer, *g*, is employed to convert the low tension direct currents

into low frequency alternating currents, preferably also of small tension. The tension of the currents is then raised in a stationary transformer T. The secondary, S, of this transformer is connected to an adjustable condenser, C, which discharges through the gap or discharger, *d d*, placed in either of the ways indicated, through the primary P of a disruptive discharge coil, the high frequency currents being obtained from the secondary s of this coil, as described on previous occasions. This will undoubtedly be found the cheapest and most convenient way of converting direct currents.

The three branches of the circuit A represent the usual cases met in practice when alternating currents are converted. In Fig. 1*b* a condenser C, generally of large capacity, is connected to the circuit L containing the devices *l l*, *m m*. The devices *m m* are supposed to be of high self-induction, so as to bring the frequency of the circuit more or less to that of the dynamo. In this instance the discharger *d d* should best have a number of makes and breaks per second equal to twice the frequency of the dynamo. If not so, then it should have at least a number equal to a multiple or even fraction of the dynamo frequency. It should be observed, referring to 1*b*, that the conversion to a high potential is also effected when the discharger *d d*, which is shown in the sketch, is omitted. But the effects which are produced by currents which rise instantly to high values, as in a disruptive discharge, are entirely different from those produced by dynamo currents which rise and fall harmonically. So, for instance, there might be in a given case a number of makes and breaks at *d d* equal to just twice the frequency of the dynamo; or in other words there may be the same number of fundamental oscillations as would be produced without

the discharge gap, and there might even not be any quicker superimposed vibration; yet the differences of potential at the various points of the circuit, the impedence and other phenomena, dependent upon the rate of change, will bear no similarity in the two cases. Thus, when working with currents discharging disruptively, the element chiefly to be considered is not the frequency, as a student might be apt to believe, but the rate of change per unit of time. With low frequencies, in a certain measure, the same effects may be obtained as with high frequencies, provided the rate of change is sufficiently great. So if a low frequency current is raised to a potential of, say, 75,000 volts and the high tension current passed through a series of high resistance lamp filaments, the importance of the rarefied gas surrounding the filament is clearly noted, as will be seen later; or, if a low frequency current of several thousand amperes is passed through a metal bar, striking phenomena of impedence are observed, just as with currents of high frequencies. But it is, of course, evident that with low frequency currents it is impossible to obtain such rates of change per unit of time as with high frequencies, hence the effects produced by the latter are much more prominent. It was deemed advisable to make the preceding remarks, inasmuch as many more recently described effects have been unwittingly identified with high frequencies. Frequency alone in reality does not mean anything, except when an undisturbed harmonic oscillation is considered.

In the branch 3*b* a similar disposition as in 1*b* is illustrated, with the difference that the currents discharging through the gap *d d* are used to induce currents in the secondary s of a transformer T. In such case the secondary should be provided with an adjustable condenser for the purpose of tuning it to the primary.

Fig. 2*b* illustrates a plan of alternate current high frequency conversion, which is most frequently used and which is found to be most convenient. This plan has been dwelt upon in detail on previous occasions and need not be described here.

Some of these results were obtained by the use of a high frequency alternator. A description of such machines will be found in my original paper before the American Institute of Electrical Engineers, and in periodicals of that period, notably in *The Electrical Engineer* of March 18th, 1891.

I will now proceed with the experiments.

ON PHENOMENA PRODUCED BY ELECTROSTATIC FORCE.

The first class of effects I intend to show you are effects produced by electrostatic force. It is the force which governs the motion of the atoms, which causes them to collide and develop the life-sustaining energy of heat and light, and which causes them to aggregate in an infinite variety of ways, according to Nature's fanciful designs, and to form all these wondrous structures we perceive around us; it is, in fact, if our present views be true, the most important force for us to consider in Nature. As the term *electrostatic* might imply a steady electric condition, it should be remarked that in these experiments the force is not constant, but varies at a rate which may be considered moderate, about one million times a second, or thereabouts. This enables me to produce many effects which are not producible with an unvarying force.

When two conducting bodies are insulated and electrified, we say that an electrostatic force is acting between them. This force manifests itself in attractions, repulsions and stresses in the bodies and space or medium without. So great may be the strain exerted

in the air, or whatever separates the two conducting bodies, that it may break down, and we observe sparks or bundles of light, or streamers, as they are called. These streamers form abundantly when the force through the air is rapidly varying. I will illustrate this action of electrostatic force in a novel experiment in which I will employ the induction coil before referred to. The coil is contained in a trough filled with oil, and placed under the table. The two ends of the secondary wire pass through the two thick columns of hard rubber, which protrude to some height above the table. It is necessary to insulate the ends or terminals of the secondary heavily with hard rubber, because even dry wood is by far too poor an insulator for these currents of enormous potential differences. On one of the terminals of the coil I have placed a large sphere of sheet brass, which is connected to a larger insulated brass plate, in order to enable me to perform the experiments under conditions which, as you will see, are more suitable for this experiment. I now set the coil to work and approach the free terminal with a metallic object held in my hand; this simply to avoid burns. As I approach the metallic object to a distance of eight or ten inches a torrent of furious sparks breaks forth from the end of the secondary wire, which passes through the rubber column. The sparks cease when the metal in my hand touches the wire. My arm is now traversed by a powerful electric current, vibrating at about the rate of one million times a second. All around me the electrostatic force makes itself felt, and the air molecules and particles of dust flying about are acted upon and are hammering violently against my body. So great is this agitation of the particles that when the lights are turned out you may see streams of feeble light appear on some parts of my body. When such a streamer breaks out

on any part of the body it produces a sensation like the pricking of a needle. Were the potentials sufficiently high, and the frequency of the vibration rather low, the skin would probably be ruptured under the tremendous strain, and the blood would rush out with great force in the form of fine spray or jet so thin as to be invisible, just as oil will when placed on the positive terminal of a Holtz machine. This breaking through of the skin, though it may seem impossible at first, would perhaps occur by reason of the tissues under the skin being incomparably better conducting. This, at least, appears plausible, judging from some observations.

I can make these streams of light visible to all, by touching with the metallic object one of the terminals as before, and approaching my free hand to the brass sphere, which is connected to the second terminal of the coil. As the hand is approached the air between it and the sphere, or in the immediate neighborhood, is more violently agitated, and you see streams of light now break forth from my finger tips and from the whole hand (Fig. 5). Were I to approach the hand closer, powerful sparks would jump from the brass sphere to my hand, which might be injurious. The streamers offer no particular inconvenience, except that in the ends of the finger tips a burning sensation is felt. They should not be confounded with those produced by an influence machine, because in many respects they behave differently. I have attached the brass sphere and plate to one of the terminals in order to prevent the formation of visible streamers on that terminal, also in order to prevent sparks from jumping at a considerable distance. Besides, the attachment is favorable for the working of the coil.

The streams of light which you have observed issuing from my hand are due to a potential of about 200,000

volts, alternating in rather irregular intervals, something like a million times a second. A vibration of the same amplitude, but four times as fast, to maintain which over 3,000,000 volts would be required, would be more than sufficient to envelop my body in a complete sheet of flame. But this flame would not burn me up; quite contrarily, the probability is that I would not be injured in the least. Yet a hundredth part of that energy, otherwise directed, would be amply sufficient to kill a person.

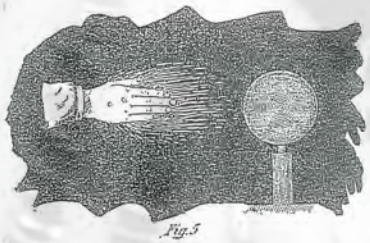


Fig. 5.—Illustrating the Effect of Varying Electrostatic Force with a Transformer of 200,000 Volts Pressure.

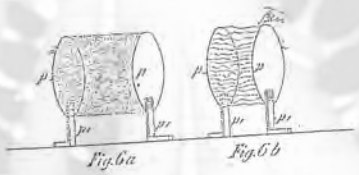
The amount of energy which may thus be passed into the body of a person depends on the frequency and potential of the currents, and by making both of these very great, a vast amount of energy may be passed into the body without causing any discomfort, except, perhaps, in the arm, which is traversed by a true conduction current. The reason why no pain in the body is felt and no injurious effect noted, is that everywhere, if a current be imagined to flow through the body, the direction of

its flow would be at right angles to the surface; hence the body of the experimenter offers an enormous section to the current, and the density is very small, with the exception of the arm, perhaps, where the density may be considerable. But, if only a small fraction of that energy would be applied in such a way that a current would traverse the body in the same manner as a low frequency current, a shock would be received which might be fatal. A direct or low frequency alternating current is fatal, I think, principally because its distribution through the body is not uniform, as it must divide itself in minute streamlets of great density, whereby some organs are vitally injured. That such a process occurs I have not the least doubt, though no evidence might apparently exist, or be found upon examination. The surest to injure and destroy life is a continuous current, but the most painful is an alternating current of very low frequency. The expression of these views, which are the result of long continued experiment and observation, both with steady and varying currents, is elicited by the interest which is at present taken in this subject, and by the manifestly erroneous ideas which are daily propounded in journals on this subject.

I may illustrate an effect of the electrostatic force by another striking experiment, but before, I must call your attention to one or two facts. I have said before that when the medium between two oppositely electrified bodies is strained beyond a certain limit it gives way and, stated in popular language, the opposite electric charges unite and neutralize each other. This breaking down of the medium occurs principally when the force acting between the bodies is steady, or varies at a moderate rate. Were the variation sufficiently rapid, such a destructive break would not occur, no matter how great the force, for all the energy would be spent

in radiation, convection and mechanical and chemical action. Thus the *spark* length, or greatest distance through which a *spark* will jump between the electrified bodies is the smaller, the greater the variation or time rate of change. But this rule may be taken to be true only in a general way, when comparing rates which are widely different.

I will show you by an experiment the difference in the effect produced by a rapidly varying and a steady or moderately varying force. I have here two large circular brass plates *pp* (Fig. 6*a* and Fig. 6*b*), supported on



FIGS. 6*a*, 6*b*.—ILLUSTRATING THE EFFECTS OF RAPIDLY VARYING AND STEADY ELECTROSTATIC FORCE.

movable insulating stands on the table, connected to the ends of the secondary of a similar coil to the one used before. I place the plates ten or twelve inches apart and set the coil to work. You see the whole space between the plates, nearly two cubic feet, filled with uniform light, Fig. 6*a*. This light is due to the streamers you have seen in the first experiment, which are now much more intense. I have already pointed out the importance of these streamers in commercial apparatus and their still greater importance in some purely scientific investigations. Often they are too

weak to be visible, but they always exist, consuming energy and modifying the action of the apparatus. When intense, as they are at present, they produce ozone in great quantity, and, also, as Professor Crookes has pointed out, nitrous acid. So quick is the chemical action, that if a coil such as this one is worked for a very long time it will make the atmosphere of a small room unbearable, for the eyes and throat are attacked. But when moderately produced, the streamers refresh the atmosphere wonderfully, like a thunder-storm, and exercise unquestionably a beneficial effect.

In this experiment the force acting between the plates changes in intensity and direction at a very rapid rate. I will now make the rate of change per unit of time much smaller. This I effect by rendering the discharges through the primary of the induction coil less frequent, and also by diminishing the rapidity of the vibration in the secondary. The former result is conveniently secured by lowering the electromotive force over the air gap in the primary circuit; the latter, by approaching the two brass plates to a distance of about three or four inches. When the coil is set to work you see no streamers or light between the plates, yet the medium between them is under a tremendous strain. I still further augment the strain by raising the electromotive force in the primary circuit, and soon you see the air give way and the hall is illuminated by a shower of brilliant and noisy sparks, 6*b*. These sparks could be produced, also, with unvarying force. They have been for many years a familiar phenomenon, though they were usually obtained from entirely different apparatus. In describing these two phenomena so radically different in appearance, I have advisedly spoken of a "force" acting between the plates. It would be in accordance with accepted views to say that there was an "alternating

electromotive force" acting between the plates. This term is quite proper and applicable in all cases where there is evidence of at least a possibility of an essential inter-dependence of the electric state of the plates or electric action in their neighborhood; but if the plates were removed to an infinite distance, or if at a finite distance, there is no probability or necessity whatever for such dependence. I prefer to use the term "electrostatic force," and to say that such a force is acting around each plate or electrified insulated body in general. There is an inconvenience in using this expression, as the term incidentally means a steady electric condition; but a proper nomenclature will eventually settle this difficulty.

I now return to the experiment to which I have already alluded, and with which I desire to illustrate a striking effect produced by a rapidly varying electrostatic force. I attach to the end of the wire *l* (Fig. 7), which is in connection with one of the terminals of the secondary of the induction coil, an exhausted bulb, *b*. This bulb contains a thin carbon filament, *f*, which is fastened to a platinum wire, *w*, sealed in the glass and leading outside of the bulb, where it connects to the wire *l*. The bulb may be exhausted to any degree attainable with ordinary apparatus. Just a moment before you have witnessed the breaking down of the air between the charged brass plates. You know that a plate of glass or any other insulating material would break down in like manner. Had I, therefore, a metallic coating attached to the outside of the bulb or placed near the same, and were this coating connected to the other terminal of the coil, you would be prepared to see the glass give way if the strain were sufficiently increased. Even were the coating not connected to the other terminal, but to an insulated plate, still, if you have followed

recent developments, you would naturally expect a rupture of the glass.

But it will certainly surprise you to note that under the action of the varying electrostatic force, the glass gives way when all other bodies are removed from the bulb. In fact, all the surrounding bodies we perceive might be removed to an infinite distance without affecting the result in the slightest. When the coil is set to



FIG. 7.—BREAKING A BULB ON OPEN CIRCUIT.

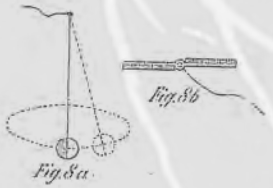
work, the glass is invariably broken through at the seal, or other narrow channel, and the vacuum is quickly impaired. Such a damaging break would not occur with a steady force, even if the same were many times greater. The break is due to the agitation of the molecules of the gas within the bulb, and outside of the same. This agitation, which is generally most violent in the narrow pointed channel near the seal,

causes a heating and rupture of the glass. The rupture would, however, not occur, not even with a varying force, if the medium filling the inside of the bulb, and that surrounding it were perfectly homogeneous. The break occurs much quicker if the top of the bulb is drawn out into a fine fibre. In bulbs used with these coils such narrow, pointed channels must therefore be avoided.

When a conducting body is immersed in air, or similar insulating medium, consisting of, or containing, small, freely movable particles capable of being electrified, and when the electrification of the body is made to undergo a very rapid change—which is equivalent to saying that the electrostatic force acting around the body is varying in intensity—the small particles are attracted and repelled, and their violent impacts against the body may cause a mechanical motion of the latter. Phenomena of this kind are noteworthy, inasmuch as they have not been observed before with apparatus such as has been commonly in use. If a very light conducting sphere be suspended on an exceedingly fine wire, and charged to a steady potential, however high, the sphere will remain at rest. Even if the potential should be rapidly varying, provided that the small particles of matter, molecules or atoms, are evenly distributed, no motion of the sphere should result. But if one side of the conducting sphere is covered with a thick insulating layer, the impacts of the particles will cause the sphere to move about, generally in irregular curves, Fig. 8*a*. In like manner, as I have shown on a previous occasion, a fan of metal sheet, Fig. 8*b*, covered partially with insulating material as indicated, and placed upon the terminal of the coil so as to turn freely in it, is spun around.

All these phenomena you have witnessed, and others

which will be shown later are due to the presence of a medium like air, and would not occur in a continuous medium. The action of the air may be illustrated still



FIGS. 8*a*, 8*b*.—MECHANICAL MOTIONS PRODUCED BY VARYING ELECTROSTATIC FORCE IN A GASEOUS MEDIUM.

better by the following experiment. I take a glass tube *t*, Fig. 9, of about an inch in diameter, which has a platinum wire *w* sealed in the lower end, and to which



FIG. 9.—SHOWING THE EFFECT OF THE AIR.

is attached a thin lamp filament *f*. I connect the wire with the terminal of the coil and set the coil to work. The platinum wire is now electrified positively and

negatively in rapid succession, and the wire and air inside of the tube are rapidly heated by the impacts of the particles, which may be so violent as to render the filament incandescent. But if I pour oil in the tube, just as soon as the wire is covered with the oil, all action apparently ceases, and there is no marked evidence of heating. The reason of this is that the oil is a practically continuous medium. The displacements in such a continuous medium are, with these frequencies, to all appearance incomparably smaller than in air, hence the work performed in such a medium is insignificant. But oil would behave very differently with frequencies many times as great, for even though the displacements be small, if the frequency were much greater, considerable work might be performed in the oil.

The electrostatic attractions and repulsions between bodies of measurable dimensions are, of all the manifestations of this force, the first so-called *electrical* phenomena noted. But, though they have been known to us for many centuries, the precise nature of the mechanism concerned in these actions is still unknown to us, and has not been even quite satisfactorily explained. What kind of mechanism must that be? We cannot help wondering when we observe two magnets attracting and repelling each other with a force of hundreds of pounds, with apparently nothing between them. We have in our commercial dynamos magnets capable of sustaining in mid-air tons of weight. But what are even these forces acting between magnets when compared with the tremendous attractions and repulsions produced by electrostatic force, to which there is apparently no limit as to intensity. In lightning discharges bodies are often charged to so high a potential that they are thrown away with inconceivable force, and torn asunder, or shattered into fragments. Still, even such effects cannot

compare with the attractions and repulsions which exist between charged molecules or atoms, and which are sufficient to project them with speeds of many kilometres a second, so that under their violent impact bodies are rendered highly incandescent and are volatilized. It is of special interest for the thinker who inquires into the nature of these forces to note that, whereas the actions between individual molecules or atoms occur seemingly under any condition, the attractions and repulsions of bodies of measurable dimensions imply a medium possessing insulating properties. So, if air, either by being rarefied or heated, is rendered more or less conducting, these actions between two electrified bodies practically cease, while the actions between the individual atoms continue to manifest themselves.

An experiment may serve as an illustration and as a means of bringing out other features of interest. Some time ago I showed that a lamp filament or wire mounted in a bulb and connected to one of the terminals of a high tension secondary coil is set spinning, the top of the filament generally describing a circle. This vibration was very energetic when the air in the bulb was at ordinary pressure, and became less energetic when the air in the bulb was strongly compressed; it ceased altogether when the air was exhausted, so as to become comparatively good conducting. I found at that time that no vibration took place when the bulb was very highly exhausted. But I conjectured that the vibration which I ascribed to the electrostatic action between the walls of the bulb and the filament should take place, also, in a highly exhausted bulb. To test this under conditions which were more favorable, a bulb like the one in Fig. 10 was constructed. It comprised a globe, *b*, in the neck of which was sealed a platinum wire, *w*, carrying a thin lamp filament, *f*. In the lower part of the globe a tube,

l, was sealed so as to surround the filament. The exhaustion was carried as far as it was practicable with the apparatus employed.

This bulb verified my expectation, for the filament was set spinning when the current was turned on, and became incandescent. It also showed another interesting feature bearing upon the preceding remarks, namely, when the filament had been kept incandescent some time the narrow tube and the space inside were brought to an elevated temperature, and as the gas in the tube

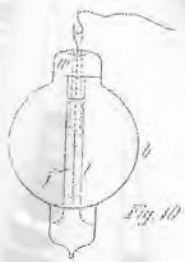


FIG. 10.—SHOWING THE INFLUENCE OF THE CONDUCTIVITY OF THE MEDIUM UPON ELECTROSTATIC ACTIONS THROUGH MEASURABLE DISTANCE.

then became conducting, the electrostatic attraction between the glass and the filament became very weak or ceased, and the filament came to rest. When it came to rest it would glow far more intensely. This was probably due to its assuming the position in the centre of the tube where the molecular bombardment was most intense, and also partly to the fact that the individual impacts were more violent, and that no part of the supplied energy was converted into mechanical movement. Since, in accordance with accepted views, in this experiment the incandescence must be attributed to the impacts of the particles, molecules or atoms in the heated space, these particles must, therefore, in order to explain such action, be assumed to behave as independent carriers of electric charges immersed in an insulating medium; yet there is no attractive force between the glass tube and the filament, because the space in the tube is, as a whole, conducting.

It is of some interest to observe in this connection that, whereas the attraction between two electrified bodies may cease, owing to the impairing of the insulating power of the medium in which they are immersed, the repulsion between the bodies may still be observed. This may be explained in a plausible way. When the bodies are placed at some distance in a poorly conducting medium, such as slightly warmed or rarefied air, and are suddenly electrified, opposite electric charges being imparted to them, these charges equalize more or less by leakage through the air. But if the bodies are similarly electrified there is less opportunity afforded for such dissipation, hence, the repulsion observed in such case is greater than the attraction. Repulsive actions in a gaseous medium are, however, as Professor Crookes has shown, enhanced by molecular bombardment.

ON CURRENT OR DYNAMIC ELECTRICITY PHENOMENA.

So far, I have considered principally effects produced by a varying electrostatic force in an insulating medium, such as air. When such a force is acting upon a conducting body of measurable dimensions it causes within the same or on its surface displacements of the electricity, and gives rise to electric currents; and these produce another kind of phenomena, some of which I shall presently endeavor to illustrate. In presenting this second class of electrical effects I will avail myself prin-

cipally of such as are producible without any return circuit, hoping to interest you the more by presenting these phenomena in a more or less novel aspect.

It has been for a long time customary, owing to the limited experience with vibratory currents, to consider an electric current as something circulating in a closed conducting path. It was astonishing at first to realize that a current may flow through the conducting path even if the latter be interrupted, and it was still more surprising to learn that sometimes it may be even easier to make a current flow under such conditions than

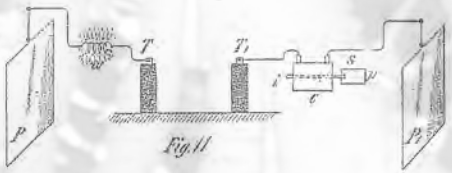


FIG 11.—SHOWING EFFECTS OF CURRENTS FLOWING THROUGH OPEN CIRCUITS.

through a closed path. But that old idea is gradually disappearing, even among practical men, and will soon be entirely forgotten.

If I connect an insulated metal plate, P, Fig. 11, to one of the terminals T of the induction coil by means of a wire, though this plate be very well insulated, a current passes through the wire when the coil is set to work. First, I wish to give you evidence that there *is* a current passing through the connecting wire. An obvious way of demonstrating this is to insert between the terminal of the coil and the insulated plate a very thin platinum or

German silver wire, *w*, and bring the latter to incandescence or fusion by the current. This requires a rather large plate or else current impulses of very high potential and frequency. Another way is to take a coil, C, Fig. 11, containing many turns of thin insulated wire, and to insert the same in the path of the current to the plate. When I connect one of the ends of the coil to the wire leading to another insulated plate, P, and its other end to the terminal T_1 of the induction coil, and set the latter to work, a current passes through the inserted coil C, and the existence of the current may be made manifest in various ways. For instance, I insert an iron core, *i*, within the coil. The current being one of very high frequency, if it be of some strength will soon bring the iron core to a noticeably higher temperature, as the hysteresis and current losses are great with such high frequencies. One might take a core of some size—laminated or not, it would matter little—but ordinary iron wire one-sixteenth or one-eighth of an inch thick is suitable for the purpose. While the induction coil is working, a current traverses the inserted coil, and only a few moments are sufficient to bring the iron wire *i* to an elevated temperature sufficient to soften the sealing wax *s*, and cause a paper washer *p*, fastened by it to the iron wire, to fall off. But with the apparatus, such as I have here, other much more interesting demonstrations of this kind can be made. I have a secondary S, Fig. 12, of coarse wire, wound upon a coil similar to the first. In the preceding experiment the current through the coil C, Fig. 11, was very small, but, there being many turns, a strong heating effect was, nevertheless, produced in the iron wire. Had I passed that current through a conductor, in order to show the heating of the latter, the current might have been too small to produce the effect desired. But with this coil

provided with a secondary winding, I can now transform the feeble current of high tension which passes through the primary P into a strong secondary current of low tension, and this current will quite certainly do what I expect. In a small glass tube, *t*, Fig. 12, I have enclosed a coiled platinum wire, *w*, this merely in order to protect the wire. On each end of the glass tube is sealed a terminal of stout wire, to which one of the ends of the platinum wire, *w*, is connected. I join the terminals of the secondary coil to these terminals and insert the primary, *p*, between the insulated plate P_1 and the terminal T_1 of the induction coil as before. The latter being set to work, the platinum wire, *w*, is instantly

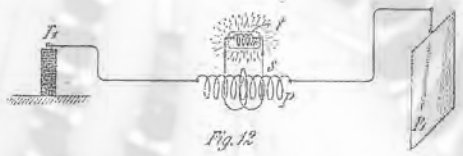


FIG. 12.—CONVERSION ON OPEN CIRCUIT WITH COIL AND INSULATED PLATE.

rendered incandescent, and can be fused, even if it be very thick.

Instead of the platinum wire I now take an ordinary fifty-volt sixteen candle power lamp. When I set the induction coil in operation the lamp filament is brought to high incandescence. It is, however, not necessary to use the insulated plate, for the lamp *l*, Fig. 13, is rendered incandescent even if the plate P_1 be disconnected. The secondary may also be connected to the primary, as indicated by the dotted line in Fig. 13, to do away more or less with the electrostatic induction or to modify the action otherwise.

I may here call attention to a number of interesting observations with the lamp. First, I disconnect one of the terminals of the lamp from the secondary s. When the induction coil plays, a glow is noted which fills the whole bulb. This glow is due to electrostatic induction. It increases when the bulb is grasped with the hand, and the capacity of the experimenter's body thus added to the secondary circuit. The secondary, in effect, is equivalent to a metallic coating, which would be placed near the primary. If the secondary, or its equivalent,

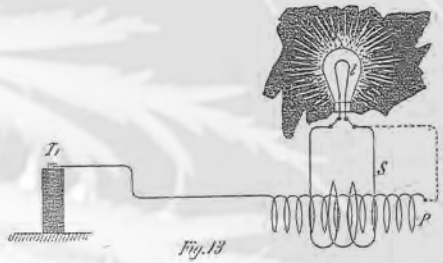
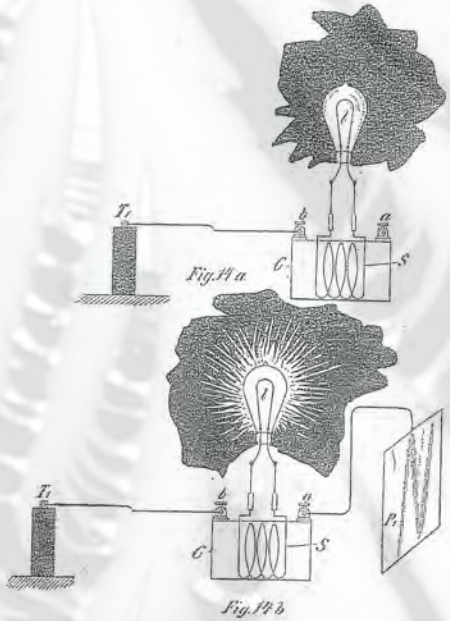


FIG. 13.—CONVERSION ON OPEN CIRCUIT WITH COIL ALONE.

the coating, were placed symmetrically to the primary, the electrostatic induction would be *nil* under ordinary conditions—that is, when a primary return circuit is used—as both halves would neutralize each other. The secondary *is* in fact placed symmetrically to the primary, but the action of both halves of the latter, when only one of its ends is connected to the induction coil, is not exactly equal; hence electrostatic induction takes place, and hence the glow in the bulb. I can nearly equalize the action of both halves of the primary by

connecting the other free end of the same to the insulated plate, as in the preceding experiment. When the plate is connected, the glow disappears. With a smaller plate it would not entirely disappear, and then it would contribute to the brightness of the filament



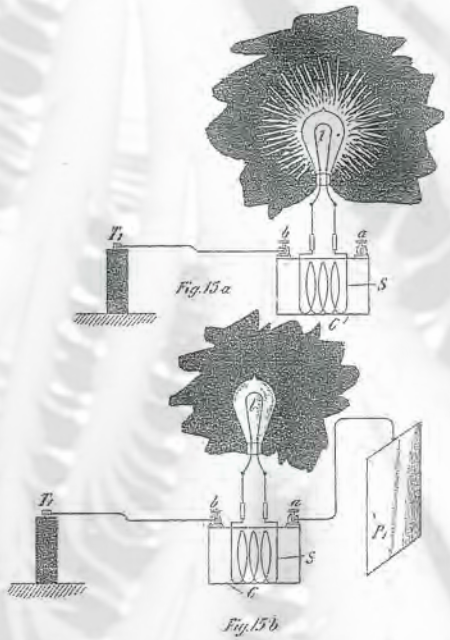
FIGS. 14*a*, 14*b*.—EFFECT OF ATTACHED PLATE WITH LOW FREQUENCIES.

when the secondary is closed, by warming the air in the bulb.

To demonstrate another interesting feature, I have adjusted the coils used in a certain way. I first connect both the terminals of the lamp to the secondary, one

end of the primary being connected to the terminal T_1 of the induction coil, and the other to the insulated plate P_1 as before. When the current is turned on, the lamp glows brightly, as shown in Fig. 14*b*, in which C is a fine wire coil and S a coarse wire secondary wound upon it. If the insulated plate P_1 is disconnected, leaving one of the ends *a* of the primary insulated, the filament becomes dark, or generally it diminishes in brightness (Fig. 14*a*). Connecting again the plate P_1, and raising the frequency of the current, I make the filament quite dark or barely red, Fig. 15*b*. Once more I will disconnect the plate. One will, of course, infer that when the plate is disconnected, the current through the primary will be weakened, that therefore the electromotive force will fall in the secondary S, and that the brightness of the lamp will diminish. This might be the case, and the result can be secured by an easy adjustment of the coils; also by varying the frequency and potential of the currents. But it is perhaps of greater interest to note that the lamp increases in brightness when the plate is disconnected (Fig. 15*a*). In this case all the energy the primary receives is now sunk into it, like the charge of a battery in an ocean cable, but most of that energy is recovered through the secondary and used to light the lamp. The current traversing the primary is strongest at the end *b*, which is connected to the terminal T_1 of the induction coil, and diminishes in strength towards the remote end *a*. But the dynamic inductive effect exerted upon the secondary S is now greater than before when the suspended plate was connected to the primary. These results might have been produced by a number of causes. For instance, the plate P_1 being connected, the reaction from the coil C may be such as to diminish the potential at the terminal T_1 of the induction coil, and therefore weaken the current through the primary

of the coil c. Or the disconnecting of the plate may diminish the capacity effect with relation to the primary of the latter coil to such an extent that the current through it is diminished, though the potential at the terminal T_1 of the induction coil may be the same,



FIGS. 15*a*, 15*b*.—EFFECT OF ATTACHED PLATE WITH HIGH FREQUENCIES.

or even higher. Or the result might have been produced by the change of phase of the primary and secondary currents and consequent reaction. But the chief determining factor is the relation of the self-induc-

tion and capacity of coil c and plate P_1, and the frequency of the currents. The greater brightness of the filament in Fig. 15*a*, is, however, in part due to the heating of the rarefied gas in the lamp by electrostatic induction, which, as before remarked, is greater when the suspended plate is disconnected.

Still another feature of some interest I may here bring to your attention. When the insulated plate is disconnected and the secondary of the coil opened, by approaching a small object to the secondary but very small sparks can be drawn from it, showing that the electrostatic induction is small in this case. But upon the secondary being closed upon itself or through the lamp, the filament glowing brightly, strong sparks are obtained from the secondary. The electrostatic induction is now much greater, because the closed secondary determines a greater flow of current through the primary, and principally through that half of it which is connected to the induction coil. If, now, the bulb be grasped with the hand, the capacity of the secondary with reference to the primary is augmented by the experimenter's body, and the luminosity of the filament is increased; the incandescence now being due partly to the flow of current through the filament, and partly to the molecular bombardment of the rarefied gas in the bulb.

The preceding experiments will have prepared one for the next following results of interest obtained in the course of these investigations. Since I can pass a current through an insulated wire by merely connecting one of its ends to the source of electrical energy; since I can induce by it another current, magnetize an iron core, and, in short, perform all operations as though a return circuit were used, clearly I can also drive a motor by the aid of only one wire. On a former occasion I have described a simple form of motor, comprising a single exciting

coil, an iron core and disc.

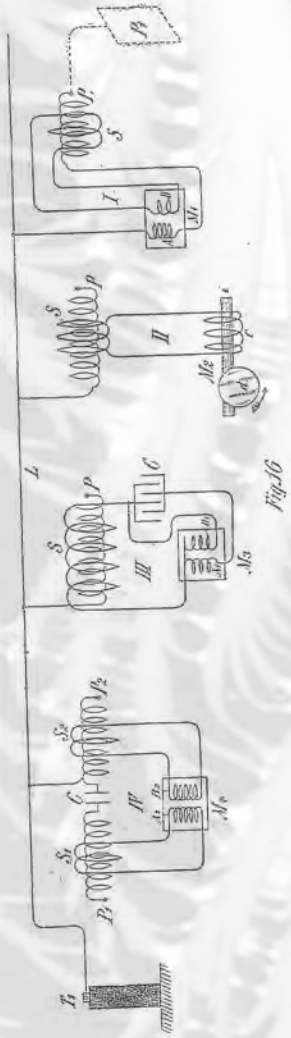


Fig. 16.—Ways of Operating Motors with Only One Lead.

Fig. 16 illustrates a modified way of operating such an alternate current motor by currents induced in a transformer connected to one lead, and several other arrangements of circuits for operating a certain class of alternate motors founded on the action of currents of differing phase. In view of the present state of the art, it is thought sufficient to describe these arrangements in a few words only. In the diagram, Fig. 16 II shows a primary coil, P, connected with one of its ends to the line L, leading from a high tension transformer terminal, T_1. In inductive relation to this primary P is a secondary S, of coarse wire, in the circuit of which is a coil, *c*. The currents induced in the secondary energize the iron core *i*, which is preferably, but not necessarily, subdivided, and set the metal disc *d* in rotation. Such a motor, M_2, as diagrammatically shown in Fig. 16 II, has been called a "magnetic lag motor," but this expression may be objected to by those who attrib-

ute the rotation of the disc to eddy currents circulating in minute paths when the core *i* is finally subdivided. In order to operate such a motor effectively on the plan indicated, the frequencies should not be too high—not more than four or five thousand—though the rotation is produced even with ten thousand per second or more.

In Fig. 16 I, a motor M_1, having two energizing circuits, A and B, is diagrammatically indicated. The circuit A is connected to the line L, and in series with it is a primary P, which may have its free end connected to an insulated plate P_1, such connection being indicated by the dotted lines. The other motor circuit B is connected to the secondary S, which is in inductive relation to the primary P. When the transformer terminal T_1 is alternately electrified, currents traverse the open line L and also circuit A and primary P. The currents through the latter induce secondary currents in the circuit S, which pass through the energizing coil B of the motor. The currents through the secondary S and those through the primary P differ in phase ninety degrees, or nearly so, and are capable of rotating an armature placed in inductive relation to the circuits A and B.

In Fig. 16 III, a similar motor M_3, with two energizing circuits A_1 and B_1, is illustrated. A primary P, connected with one of its ends to the line L, has a secondary S, which is preferably wound for a tolerably high electromotive force, and to which the two energizing circuits of the motor are connected, one directly to the ends of the secondary and the other through a condenser C, by the action of which the currents traversing the circuit A_1 and B_1 are made to differ in phase.

In Fig. 16 IV, still another arrangement is shown.

In this case two primaries P_1 and P_2 are connected to the line L, one through a condenser C of small capacity, and the other directly. The primaries are provided with secondaries S_1 and S_2, which are in series with the energizing circuits A_2 and B_2 and a motor M_2, the condenser C again serving to produce the requisite difference in the phase of the currents traversing the motor circuits. As such phase motors with two or more circuits are now well known in the art, they have been here illustrated diagrammatically. No difficulty whatever is found in operating a motor in the manner indicated or in similar ways, and although such experiments up to this day present only scientific interest, they may at a period not far distant be carried out with practical objects in view.

It is thought useful to devote here a few remarks to the subject of operating devices of all kinds by means of only one leading wire. It is quite obvious that when high frequency currents are made use of, ground connections are—at least when the electromotive force of the currents is great—better than a return wire. Such ground connections are objectionable with steady or low frequency currents, on account of destructive chemical actions of the former, and disturbing influences exerted by both on the neighboring circuits; but with high frequencies these actions practically do not exist. Still, even ground connections become superfluous when the electromotive force is very high, for soon a condition is reached when the current may be passed more economically through open than through closed conductors. Remote as might seem an industrial application of such single wire transmission of energy to one not experienced in such lines of experiment, it will not seem so to anyone who for some time has carried on investigations of such nature. Indeed, I

cannot see why such a plan should not be practicable. Nor should it be thought that for carrying out such a plan currents of very high frequency are implicitly required, for just as soon as potentials of, say, 30,000 volts are used, the single wire transmission may be effected with low frequencies, and experiments have been made by me from which these inferences are made.

When the frequencies are very high, it has been found in laboratory practice quite easy to regulate the effects in the manner shown in diagram, Fig. 17. Here two primaries, P and P_1, are shown, each connected with

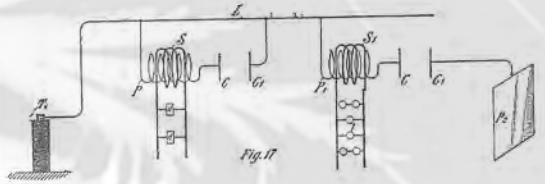


FIG. 17.—SINGLE WIRE CONVERSION AND DISTRIBUTION, WITH SIMPLE MEANS FOR REGULATING THE EFFECTS.

one of its ends to the line L, and with the other end to the condenser plates C and C^1, respectively. Near these are placed other condenser plates, C_1 C^1_1, the former being connected to the line L and the latter to an insulated larger plate P_2. On the primaries are wound secondaries s and s_1 of coarse wire, connected to the devices *m* and *d* respectively. By varying the distances of the condenser plates C and C^1, and C_1 and C_1^1, the currents through the secondaries s and s_1 are varied in intensity. The curious feature is the great sensitiveness, the slightest change in the distance of the plates.

producing considerable variations in the intensity or strength of the currents. The sensitiveness may be rendered extreme by making the frequency such that the primary itself, without any plate attached to its free end, satisfies, in conjunction with the closed secondary, the condition of resonance. In such condition an extremely small change in the capacity of the free terminal produces great variations. For instance, I have been able to adjust the conditions so that the mere approach of a person to the coil produces a considerable change in the brightness of the lamps attached to the secondary. Such observations and experiments possess, of course, at present chiefly scientific interest, but they may soon become of practical importance.

Very high frequencies are, of course, not practicable with motors, on account of the necessity of employing iron cores. But one may use sudden discharges of low frequency, and thus obtain certain advantages of high frequency currents without rendering the iron core entirely incapable of following the changes, and without entailing a very great expenditure of energy in the core. I have found it quite practicable to operate with such low frequency disruptive discharges of condensers alternating current motors. A certain class of such motors which I advanced a few years ago, which contain closed secondary circuits, will rotate quite vigorously when the discharges are directed through the exciting coils. One reason that such a motor operates so well with these discharges is that the difference of phase between the primary and secondary currents is ninety degrees, which is generally not the case with harmonically rising and falling currents of low frequency. It might not be without interest to show an experiment with a simple motor of this kind, inasmuch as it is commonly thought that

disruptive discharges are unsuitable for such purposes. The motor is illustrated in Fig. 18. It comprises a rather large iron core *i*, with slots on the top into which are embedded thick copper washers *c c*. In proximity to the core is a freely movable metal disc D. The core is provided with a primary exciting coil C, the ends *a* and *b* of which are connected to the terminals of the secondary S of an ordinary transformer, the primary P of the latter being connected to an alternating distribution circuit or generator G of low or moderate frequency. The terminals of the secondary S are attached to a condenser C, which discharges through

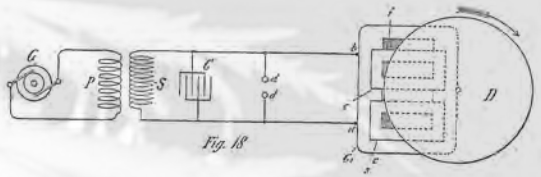
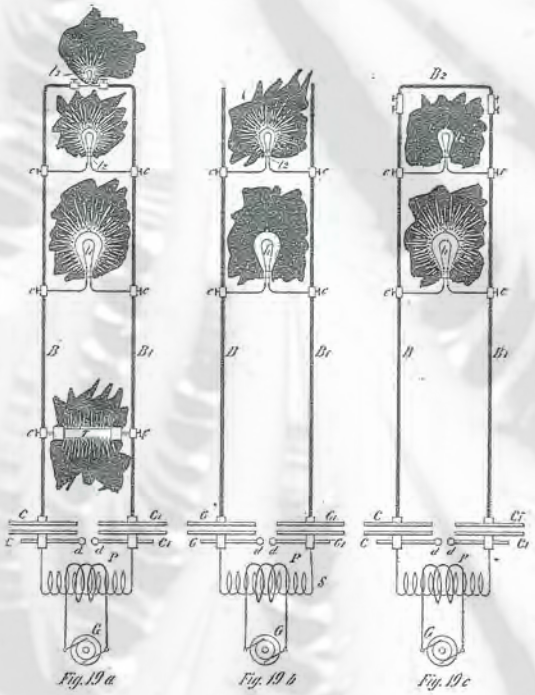


FIG. 18.—OPERATING A MOTOR BY DISRUPTIVE DISCHARGES.

an air gap *d d*, which may be placed in series or shunt to the coil C. When the conditions are properly chosen the disc D rotates with considerable effort, and the iron core *i* does not get very perceptibly hot. With currents from a high frequency alternator, on the contrary, the core gets rapidly hot, and the disc rotates with a much smaller effort. To perform the experiment properly it should be first ascertained that the disc D is not set in rotation when the discharge is not occurring at *d d*. It is preferable to use a large iron core and a condenser of large capacity, so as to bring

the superimposed quicker oscillation to a very low pitch, or to do away with it entirely. By observing certain elementary rules I have also found it practicable to operate ordinary series or shunt direct current motors with such disruptive discharges, and this can be done with or without a return wire.



FIGS. 19*a*, 19*b*, 19*c*.—IMPEDANCE PHENOMENA.

Among the various current phenomena observed, perhaps the most interesting are those of impedance presented by conductors to currents varying at a rapid rate. In my first paper before the American Institute

of Electrical Engineers I have described a few striking observations of this kind. Thus I showed that when such currents or sudden discharges are passed through a thick metal bar, there may be points at the bar only a few inches apart which have a sufficient potential difference between them to maintain at bright incandescence an ordinary filament lamp. I have also ascribed the curious behavior of rarefied gas surrounding a conductor to such sudden rushes of current. These phenomena have been since more carefully studied, and one or two novel experiments of this kind are deemed of sufficient interest to be described here.

With reference to Fig. 19*a*, B and B_1 are very stout copper bars connected at their lower ends to plates C and C_1, respectively, of a condenser, the opposite plates of the latter being connected to the terminals of the secondary S of a high tension transformer, the primary P of which is supplied with alternating currents from an ordinary low frequency dynamo, G, or distribution circuit. The condenser discharges through an adjustable gap, *d d*, as usual. By establishing a rapid vibration it was found quite easy to perform the following curious experiment: The bars B and B_1 were joined at the top by a low voltage lamp, l_3; a little lower was placed by means of clamps, *c c*, a fifty-volt lamp, l_2, and still lower another hundred-volt lamp, l_1, and, finally, at a certain distance below the latter lamp an exhausted tube, T. By carefully determining the positions of these devices it was found practicable to maintain them all at their proper illuminating power. Yet they were all connected in multiple arc to the two stout copper bars, and required widely different pressures. This experiment requires, of course, some time for adjustment, but is quite easily performed.

In Figs. 19*b* and 19*c*, two other experiments are illustrated which, unlike the previous experiment, do not

require very careful adjustments. In Fig. 20*b* two lamps, l_1 and l_2, the former a hundred-volt and the latter a fifty-volt, are placed in certain positions, as indicated, the hundred-volt lamp being below the fifty-volt lamp. When the arc is playing at *d d*, and the sudden discharges passed through the bars B B, the fifty-volt lamp will, as a rule, burn brightly, or, at least, this result is easily secured, while the hundred-volt lamp will burn very low or remain quite dark, Fig. 19*b*. Now, the bars B B may be joined at the top by a thick cross-bar B_2, and it is quite easy to maintain the hundred-volt lamp at full candle power, while the fifty-volt lamp remains dark,

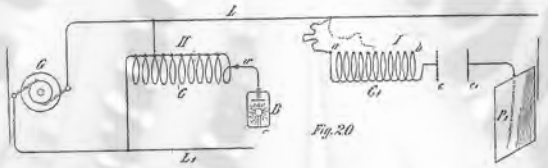


FIG. 20.—PLAN FOLLOWED IN OBSERVING THE EFFECTS OF RESONANCE.

Fig. 19*c*. These results, as I have pointed out previously, should not be considered to be due exactly to frequency, but rather to the time rate of change, which may be great even with low frequencies. A great many other results of the same kind, equally interesting, especially to those who are only used to manipulating steady currents, may be obtained, and they afford precious clues in investigating the nature of electric currents.

In the preceding experiments I have already had occasion to show some light phenomena, and it would be now proper to study these in particular; but to make

this investigation more complete, I think it necessary to first make a few remarks on the subject of electrical resonance, which has to be always observed in carrying out these experiments.

ON ELECTRICAL RESONANCE.

The effects of resonance are being more and more noted by engineers, and are becoming of great importance in the practical operation of apparatus of all kinds with alternating currents. A few general remarks may, therefore, be made concerning these effects. It is clear that if we succeed in employing the effects of resonance practically in the operation of electric devices, the return wire will, as a matter of course, become unnecessary, for the electric vibration may be conveyed with one wire just as well as, and sometimes even better than, with two. The question first to answer is, then, whether pure resonance effects are producible. Theory and experiment both show that such is impossible in Nature, for as the oscillation becomes more and more vigorous, the losses in the vibrating bodies and environing media rapidly increase, and necessarily check the vibration, which otherwise would go on increasing forever. It is a fortunate circumstance that pure resonance is not producible, for if it were there is no telling what dangers might not lie in wait for the innocent experimenter. But, to a certain degree, resonance is producible, the magnitude of the effects being limited by the imperfect conductivity and imperfect elasticity of the media, or, generally stated, by frictional losses. The smaller these losses, the more striking are the effects. The same is the case in mechanical vibration. A stout steel bar may be set in vibration by drops of water falling upon it at proper intervals; and with glass, which is more perfectly elastic, the resonance effect is still more remarkable, for

a goblet may be burst by singing into it a note of the proper pitch. The electrical resonance is the more perfectly attained, the smaller the resistance or the impedance of the conducting path, and the more perfect the dielectric. In a Leyden jar discharging through a short stranded cable of thin wires, these requirements are probably best fulfilled, and the resonance effects are, therefore, very prominent. Such is not the case with dynamo machines, transformers and their circuits, or with commercial apparatus in general, in which the presence of iron cores complicates or renders impossible the action. In regard to Leyden jars, with which resonance effects are frequently demonstrated, I would say that the effects observed are often *attributed*, but are seldom *due*, to true resonance, for an error is quite easily made in this respect. This may be undoubtedly demonstrated by the following experiment: Take, for instance, two large insulated metallic plates or spheres, which I shall designate A and B; place them at a certain small distance apart, and charge them from a frictional or influence machine to a potential so high that just a slight increase of the difference of potential between them will cause the small air or insulating space to break down. This is easily reached by making a few preliminary trials. If, now, another plate—fastened on an insulating handle and connected by a wire to one of the terminals of a high tension secondary of an induction coil, which is maintained in action by an alternator (preferably high frequency)—is approached to one of the charged bodies A or B, so as to be nearer to either one of them, the discharge will invariably occur between them; at least, it will if the potential of the coil in connection with the plate is sufficiently high. But the explanation of this will soon be found in the fact that the approached plate acts inductively upon the bodies A and B, and causes a

spark to pass between them. When this spark occurs, the charges which were previously imparted to these bodies from the influence machine must needs be lost, since the bodies are brought in electrical connection through the arc formed. Now, this arc is formed whether there be resonance or not. But even if the spark would not be produced, still there is an alternating electromotive force set up between the bodies when the plate is brought near one of them; therefore, the approach of the plate, if it *does* not always actually, will, at any rate, *tend* to break down the air space by inductive action. Instead of the spheres or plates A and B, we may take the coatings of a Leyden jar with the same result; and in place of the machine, which is a high frequency alternator preferably, because it is more suitable for the experiment and also for the argument, we may take another Leyden jar or battery of jars. When such jars are discharging through a circuit of low resistance, the same is traversed by currents of very high frequency. The plate may now be connected to one of the coatings of the second jar, and when it is brought near to the first jar just previously charged to a high potential from an influence machine, the result is the same as before, and the first jar will discharge through a small air space upon the second being caused to discharge. But both jars and their circuits need not be tuned any closer than a basso profundo is to the note produced by a mosquito, as small sparks will be produced through the air space, or, at least, the latter will be considerably more strained, owing to the setting up of an alternating electromotive force by induction, which takes place when one of the jars begins to discharge. Again, another error of a similar nature is quite easily made. If the circuits of the two jars are run parallel and close together, and

the experiment has been performed of discharging one by the other, and now a coil of wire be added to one of the circuits, whereupon the experiment does not succeed, the conclusion that this is due to the fact that the circuits are now not tuned would be far from being safe; for the two circuits act as condenser coatings, and the addition of the coil to one of them is equivalent to bridging them, at the point where the coil is placed, by a small condenser, and the effect of the latter might be to prevent the spark from jumping through the discharge space by diminishing the alternating electromotive force acting across the same. All these remarks, and many more which might be added but for fear of wandering too far from the subject, are made with the pardonable intention of cautioning the unsuspecting student, who might gain an entirely unwarranted opinion of his skill when seeing every experiment succeed; but they are in no way thrust upon the experienced as novel observations.

In order to make reliable observations of electric resonance effects, it is very desirable, if not necessary, to employ an alternator giving currents which rise and fall harmonically, as in working with make-and-break currents the observations are not always trustworthy, since many phenomena which depend on the rate of change may be produced with frequencies widely different. Even when making such observations with an alternator one is apt to be mistaken. When a circuit is connected to an alternator there are an infinite number of values for capacity and self-induction which, in conjunction, will satisfy the condition of resonance. So there are in mechanics an infinite number of tuning-forks which will respond to a note of a certain pitch, or loaded springs which have a definite period of vibration. But the resonance will be most perfectly attained in that case in

which the motion is effected with the greatest freedom. Now, in mechanics, considering the vibration in the common medium—that is, air—it is of comparatively little importance whether one tuning-fork be somewhat larger than another, because the losses in the air are not very considerable. One may, of course, enclose a tuning-fork in an exhausted vessel, and by thus reducing the air resistance to a minimum obtain better resonant action. Still, the difference would not be very great. But it would make a great difference if the tuning-fork were immersed in mercury. In the electrical vibration it is of enormous importance to arrange the conditions so that the vibration is effected with the greatest freedom. The magnitude of the resonance effect depends, under otherwise equal conditions, on the quantity of electricity set in motion, or on the strength of the current driven through the circuit. But the circuit opposes the passage of the currents by reason of its impedance and, therefore, to secure the best action, it is necessary to reduce the impedance to a minimum. It is impossible to overcome it entirely, but merely in part, for ohmic resistance cannot be overcome. But when the frequency of the impulses is very great, the flow of the current is practically determined by self-induction. Now, self-induction can be overcome by combining it with capacity. If the relation between these is such that at the frequency used they annul each other—that is, have such values as to satisfy the condition of resonance—and the greatest quantity of electricity is made to flow through the external circuit, then the best result is obtained. It is simpler and safer to join the condenser in series with the self-induction. It is clear that in such combinations there will be, for a given frequency, and considering only the fundamental vibration, values which will give the best result with the condenser in shunt to the self-

induction coil; of course, more such values than with the condenser in series. But practical conditions determine the selection. In the latter case, in performing the experiments, one may take a small self-induction and a large capacity, or a small capacity and a large self-induction; but the latter is preferable, because it is inconvenient to adjust a large capacity by small steps. By taking a coil with a very large self-induction, the critical capacity is reduced to a very small value, and the capacity of the coil itself may be sufficient. It is easy, especially by observing certain artifices, to wind a coil through which the impedance will be reduced to the value of the ohmic resistance only; and for any coil there is, of course, a frequency at which the maximum current will be made to pass through the coil. The observation of the relation between self-induction, capacity and frequency is becoming important in the operation of alternate current apparatus, such as transformers or motors, because by a judicious determination of the elements the employment of an expensive condenser becomes unnecessary. Thus it is possible to pass through the coils of an alternating current motor, under the normal working conditions, the required current with a low electromotive force, and do away entirely with the false current, and the larger the motor the easier such a plan becomes practicable; but it is necessary for this to employ currents of very high potential or high frequency.

In Fig. 20 I, is shown a plan which has been followed in the study of the resonance effects by means of a high frequency alternator. c is a coil of many turns, which is divided in small separate sections for the purposes of adjustment. The final adjustment was made sometimes with a few thin iron wires (though this is not always advisable), or with a closed secondary. The coil c is connected with one of its ends to the

line L from the alternator G, and with the other end to one of the plates c of a condenser $c\,c_1$, the plate (c_1) of the latter being connected to a much larger plate P_1. In this manner, both capacity and self-induction were adjusted to suit the dynamo frequency.

As regards the rise of potential through resonant action, of course, theoretically, it may amount to anything, since it depends on self-induction and resistance, and since these may have any value. But in practice one is limited in the selection of these values, and, besides these, there are other limiting causes. One may start with, say, 1,000 volts, and raise the electromotive force to fifty times that value, but one cannot start with 100,000 and raise it to ten times that value, because of the losses in the media, which are great, especially if the frequency is high. It should be possible to start with, for instance, two volts from a high or low frequency circuit of a dynamo, and raise the electromotive force to many hundred times that value. Thus coils of the proper dimensions might be connected each with only one of its ends to the mains from a machine of low electromotive force, and though the circuit of the machine would not be closed, in the ordinary acceptance of the term, yet the machine might be burned out if a proper resonance effect would be obtained. I have not been able to produce, nor have I observed with currents from the dynamo machine, such great rises of potential. It is possible, if not probable, that with currents obtained from apparatus containing iron, the disturbing influence of the latter is the cause that these theoretical possibilities cannot be realized. But if such is the case, I attribute it solely to the hysteresis and Faucault current losses in the core. Generally, it was necessary to transform upward, when the electromotive force was very low, and an ordinary form of induction coil was

usually employed; but sometimes the arrangement illustrated in Fig. 20 II has been found to be convenient. In this case, a coil C is made in a great many sections, a few of these being used as the primary. In this manner, both primary and secondary are adjustable. One end of the coil is connected to the line L_1 from the alternator, and the other line L is connected to the intermediate point of the coil. Such a coil, with adjustable primary and secondary, will be found also convenient in experiments with the disruptive discharge. When true resonance is obtained, the top of the wave must, of course, be on the free end of the coil, as, for instance, at the terminal of the phosphorescence bulb B. This is easily recognized by observing the potential of a point on the wire *w* near to the coil.

In connection with resonance effects and the problems of transmission of energy over a single conductor, which was previously considered, I would say a few words on a subject which constantly fills my thoughts, and which concerns the welfare of all. I mean the transmission of intelligible signals, or, perhaps, even power, to any distance without the use of wires. I am becoming daily more convinced of the practicability of the scheme; and though I know full well that the great majority of scientific men will not believe that such results can be practically and immediately realized, yet I think that all consider the developments in recent years by a number of workers to have been such as to encourage thought and experiment in this direction. My conviction has grown so strong that I no longer look upon this plan of energy or intelligence transmission as a mere theoretical possibility, but as a serious problem in electrical engineering, which must be carried out some day. The idea of transmitting intelligence without wires is the natural outcome of the most recent results of electrical

investigations. Some enthusiasts have expressed their belief that telephony to any distance by induction through the air is possible. I cannot stretch my imagination so far, but I do firmly believe that it is practicable to disturb, by means of powerful machines, the electrostatic condition of the earth, and thus transmit intelligible signals, and, perhaps, power. In fact, what is there against the carrying out of such a scheme? We now know that electric vibration may be transmitted through a single conductor. Why, then, not try to avail ourselves of the earth for this purpose? We need not be frightened by the idea of distance. To the weary wanderer counting the mile-posts, the earth may appear very large; but to that happiest of all men, the astronomer, who gazes at the heavens, and by their standard judges the magnitude of our globe, it appears very small. And so I think it must seem to the electrician for when he considers the speed with which an electric disturbance is propagated through the earth, all his ideas of distance must completely vanish.

A point of great importance would be first to know what is the capacity of the earth, and what charge does it contain if electrified. Though we have no positive evidence of a charged body existing in space without other oppositely electrified bodies being near, there is a fair probability that the earth is such a body, for by whatever process it was separated from other bodies—and this is the accepted view of its origin—it must have retained a charge, as occurs in all processes of mechanical separation. If it be a charged body insulated in space, its capacity should be extremely small—less than one-thousandth of a farad. But the upper strata of the air are conducting, and so, perhaps, is the medium in free space beyond the atmosphere, and these may contain an opposite charge. Then the capacity might be incom-

parably greater. In any case, it is of the greatest importance to get an idea of what quantity of electricity the earth contains. It is difficult to say whether we shall ever acquire this necessary knowledge, but there is hope that we may, and that is by means of electrical resonance. If ever we can ascertain at what period the earth's charge, when disturbed, oscillates with respect to an oppositely electrified system or known circuit, we shall know a fact possibly of the greatest importance to the welfare of the human race. I propose to seek for the period by means of an electrical oscillator or a source of alternating electric currents. One of the terminals of the source would be connected to earth, as, for instance, to the city water mains, the other to an insulated body of large surface. It is possible that the outer conducting air strata or free space contains an opposite charge, and that, together with the earth, they form a condenser of very large capacity. In such case the period of vibration may be very low, and an alternating dynamo machine might serve for the purpose of the experiment. I would then transform the current to a potential as high as it would be found possible, and connect the ends of the high tension secondary to the ground and to the insulated body. By varying the frequency of the currents, and carefully observing the potential of the insulated body, and watching for the disturbance at various neighboring points of the earth's surface, resonance might be detected. Should, as the majority of scientific men in all probability believe, the period be extremely small, then a dynamo machine would not do, and a proper electrical oscillator would have to be produced, and perhaps it might not be possible to obtain such rapid vibrations. But whether this be possible or not, and whether the earth contains a charge or not, and whatever may be its period

of vibration, it certainly is possible—for of this we have daily evidence—to produce some electrical disturbance sufficiently powerful to be perceptible by suitable instruments at any point of the earth's surface.

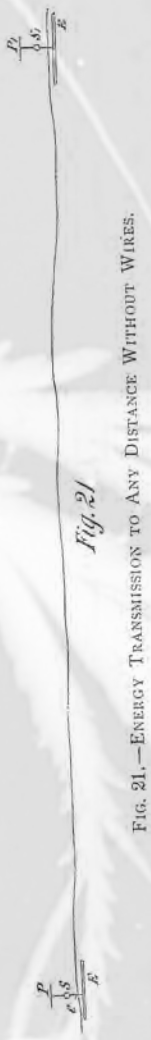


Fig. 21.—Energy Transmission to Any Distance Without Wires.

Assume that a source of alternating currents, S, be connected, as in Fig. 21, with one of its terminals to earth (convenient to the water mains), and with the other to a body of large surface, P. When the electric oscillation is set up, there will be a movement of electricity in and out of P, and alternating currents will pass through the earth, converging to or diverging from the point C, where the ground connection is made. In this manner neighboring points on the earth's surface within a certain radius will be disturbed. But the disturbance will diminish with the distance, and the distance at which the effect will still be perceptible will depend on the quantity of electricity set in motion. Since the body P is insulated, in order to displace a considerable quantity the potential of the source must be excessive, since there would be limitations as to the surface of P. The conditions might be adjusted so that the generator or source, S, will set up the same electrical movement as though its circuit were closed. Thus it is certainly practicable to impress an electric vibration, at least of a certain low period, upon the earth by means of proper machinery. At what distance such a vibration might

be made perceptible can only be conjectured. I have on another occasion considered the question how the earth might behave to electric disturbances. There is no doubt that, since in such an experiment the electrical density at the surface could be but extremely small, considering the size of the earth, the air would not act as a very disturbing factor, and there would be not much energy lost through the action of the air, which would be the case if the density were great. Theoretically, then, it could not require a great amount of energy to produce a disturbance perceptible at great distance, or even all over the surface of the globe. Now, it is quite certain that at any point within a certain radius of the source, s, a properly adjusted self-induction and capacity device can be set in action by resonance. But not only can this be done, but another source, s_1, Fig. 21, similar to s, or any number of such sources, can be set to work in synchronism with the latter, and the vibration thus intensified and spread over a large area, or a flow of electricity produced to or from the source s_1, if the same be of opposite phase to the source s. I think that, beyond doubt, it is possible to operate electrical devices in a city, through the ground or pipe system, by resonance from an electrical oscillator located at a central point. But the practical solution of this problem would be of incomparably smaller benefit to man than the realization of the scheme of transmitting intelligence, or, perhaps, power, to any distance through the earth or environing medium. If this is at all possible, distance does not mean anything. Proper apparatus must first be produced, by means of which the problem can be attacked, and I have devoted much thought to this subject. I am firmly convinced that it can be done, and hope that we shall live to see it done.

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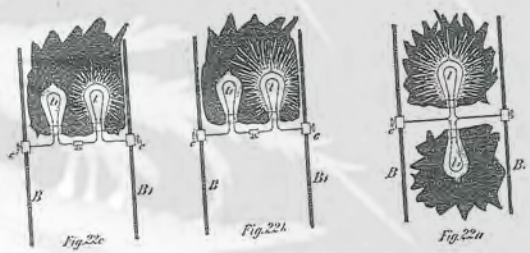
ON THE LIGHT PHENOMENA PRODUCED BY HIGH FREQUENCY CURRENTS OF HIGH POTENTIAL, AND GENERAL REMARKS RELATING TO THE SUBJECT.

Returning now to the light effects, which it has been the chief object to investigate, it is thought proper to divide these effects into four classes: 1. Incandescence of a solid. 2. Phosphorescence. 3. Incandescence or phosphorescence of a rarefied gas; and, 4. Luminosity produced in a gas at ordinary pressure. The first question is, How are these luminous effects produced? In order to answer this question as satisfactorily as I am able to do in the light of accepted views, and with the experience acquired, and to add some interest to this demonstration, I shall dwell here upon a feature which I consider of great importance, inasmuch as it promises, besides, to throw a better light upon the nature of most of the phenomena produced by high frequency electric currents. I have on other occasions pointed out the great importance of the presence of the rarefied gas, or atomic medium in general, around the conductor through which alternate currents of high frequency are passed, as regards the heating of the conductor by the currents. My experiments described some time ago have shown that the higher the frequency and potential difference of the currents, the more important becomes the rarefied gas in which the conductor is immersed, as a factor of the heating. The potential difference, however, is, as I then pointed out, a more important element than the frequency. When both of these are sufficiently high, the heating may be almost entirely due to the presence of the rarefied gas. The experiments to follow will show the importance of the rarefied gas, or generally of gas at ordinary or other pressure, as regards the incandescence or other luminous effects produced by currents of this kind.

I take two ordinary fifty-volt sixteen candle power lamps which are in every respect alike, with the exception that one has been opened at the top and the air has filled the bulb, while the other is at the ordinary degree of exhaustion of commercial lamps. When I attach the lamp which is exhausted to the terminal of the secondary of the coil, which I have already used, as in experiments illustrated in Fig. 15*a*, for instance, and turn on the current, the filament, as you have before seen, comes to high incandescence. When I attach the second lamp, which is filled with air, instead of the former, the filament still glows, but much less brightly. This experiment illustrates only in part the truth of the statements before made. The importance of the filament's being immersed in rarefied gas is plainly noticeable, but not to such a degree as might be desirable. The reason is that the secondary of this coil is wound for low tension, having only 150 turns, and the potential difference at the terminals of the lamp is therefore small. Were I to take another coil with many more turns in the secondary, the effect would be increased, since it depends partially on the potential difference, as before remarked. But since the effect likewise depends on the frequency, it may be properly stated that it depends on the time rate of the variation of the potential difference. The greater this variation, the more important becomes the gas as an element of heating. I can produce a much greater rate of variation in another way, which, besides, has the advantage of doing away with the objections which might be made in the experiment just shown, even if both the lamps were connected in series or multiple arc to the coil, namely, that in consequence of the reactions existing between the primary and secondary coil, the conclusions are rendered uncertain.

This result I secure by charging from an ordinary transformer, which is fed from the alternating current supply station, a battery of condensers, and discharging the latter directly through a circuit of small self-induction, as before illustrated in Figs. 19*a*, 19*b*, 19*c*.

In Figs. 22*a*, 22*b* and 22*c*, the heavy copper bars B B_1, are connected to the opposite coatings of a battery of condensers, or generally in such way that the high frequency or sudden discharges are made to traverse them. I connect first an ordinary fifty-volt incandescent lamp to the bars by means of the clamps *c c*. The discharges being passed through the lamp, the filament is rendered incandescent, though the current through it is very small, and would not be nearly sufficient to produce a visible effect under the conditions of ordinary use of the lamp. Instead of this I now attach to the bars another lamp exactly like the first, but with the seal broken off, the bulb being therefore filled with air at ordinary pressure. When the discharges are directed through the filament, as before, it does not become incandescent. But the result might still be attributed to one of the



FIGS. 22*a*, 22*b*, 22*c*.—SHOWING THE EFFECT OF THE PRESENCE OF A GASEOUS MEDIUM.

many possible reactions. I therefore connect both the lamps in multiple arc, as illustrated in Fig. 22*a*. Passing the discharges through both the lamps, again the filament in the exhausted lamp l glows very brightly, while that in the non-exhausted lamp l_1 remains dark, as previously. But it should not be thought that the latter lamp is taking only a small fraction of the energy supplied to both the lamps; on the contrary, it may consume a considerable portion of the energy, and it may become even hotter than the one which burns brightly. In this experiment the potential difference at the terminals of the lamp varies in sign, theoretically, three to four million times a second. The ends of the filaments are correspondingly electrified, and the gas in the bulbs is violently agitated, and a large portion of the supplied energy is thus converted into heat. In the non-exhausted bulb there being a few million times more gas molecules than in the exhausted one, the bombardment, which is most violent at the ends of the filament, in the neck of the bulb, consumes a large portion of the energy without producing any visible effect. The reason is that, there being many molecules, the bombardment is quantitatively considerable, but the individual impacts are not very violent, as the speeds of the molecules are comparatively small, owing to the small free path. In the exhausted bulb, on the contrary, the speeds are very great and the individual impacts are violent, and, therefore, better adapted to produce a visible effect. Besides, the convection of heat is greater in the former bulb. In both the bulbs the current traversing the filaments is very small, incomparably smaller than that which they require on an ordinary low frequency circuit. The potential difference, however, at the ends of the filaments is very great, and might be possibly 20,000 volts, or more, if the filaments were

straight and their ends far apart. In the ordinary lamp a spark generally occurs between the ends of the filament, or between the platinum wires outside, before such a difference of potential can be reached.

It might be objected, in the experiment before shown, that the lamps being in multiple arc, the exhausted lamp might take a much larger current, and that the effect observed might not be exactly attributable to the action of the gas in the bulbs. Such objections will lose much weight if I connect the lamps in series with the same result. When this is done and the discharges are directed through the filaments, it is again noted that the filament in the non-exhausted bulb l_1 remains dark, while that in the exhausted one (l) glows even more intensely than under its normal conditions of working, Fig. 22*b*. According to general ideas, the current through the filaments should now be the same, were it not modified by the presence of the gas around the filaments.

At this juncture I may point out another interesting feature which illustrates the effect of the rate of change of potential of the currents. I will leave the two lamps connected in series to the bars B, B_1 as in the previous experiment, Fig. 22*b*, but will presently reduce considerably the frequency of the currents, which was excessive in the experiment just before shown. This I may do by inserting a self-induction coil in the path of the discharges, or by augmenting the capacity of the condensers. When I now pass these low-frequency discharges through the lamps, the exhausted lamp l again is as bright as before, but it is noted also that the non-exhausted lamp l_1 glows, though not quite as intensely as the other. Reducing the current through the lamps, I may bring the filament in the latter lamp to redness, and, though the filament in the exhausted

lamp *l* is bright, Fig. 22*c*, the degree of its incandescence is much smaller than in Fig. 22*b*, when the currents were of a much higher frequency.

In these experiments the gas acts in two opposite ways in determining the degree of the incandescence of the filaments; that is, by convection and by bombardment. The higher the frequency and potential of the currents, the more important becomes the bombardment. The convection, on the contrary, should be the smaller, the higher the frequency. When the currents are steady there is practically no bombardment, and convection may, therefore, with such currents, also considerably modify the degree of incandescence, and produce results similar to those just before shown. Thus, if two lamps, exactly alike, one exhausted and one not exhausted, are connected in multiple arc or series to a direct current machine, the filament in the non-exhausted lamp will require a considerably greater current to be rendered incandescent. This result is entirely due to convection, and the effect is the more prominent the thinner the filament. Professor Ayrton and Mr. Kilgour some time ago published quantitative results concerning the thermal emissivity by radiation and convection, in which the effect of thin wires were clearly shown. This effect may be strikingly illustrated by preparing a number of small short glass tubes, each containing through its axis the thinnest obtainable platinum wire. If these tubes be highly exhausted, a number of them may be connected in multiple arc to a direct current machine, and all of the wires may be kept at incandescence with a smaller current than that required to render incandescent a single one of the wires if the tube be not exhausted. Could the tubes be so highly exhausted that convection would be *nil*, then the relative amounts of heat given off by convection and radiation could be determined without

the difficulties attending thermal quantitative measurements. If a source of electric impulses of high frequency and very high potential is employed, a still greater number of the tubes may be taken, and the wires rendered incandescent by a current not capable of warming perceptibly a wire of the same size immersed in air at ordinary pressure, and conveying the energy to all of them.

I may here describe a result which is still more interesting, and to which I have been led by the observation of these phenomena. I noted that small differences in the density of the air produced a considerable difference in the degree of incandescence of the wires, and I thought that, since in a tube through which a luminous discharge is passed the gas is generally not of uniform density, a very thin wire contained in the tube might be rendered incandescent at certain places of smaller density of the gas, while it would remain dark at the places of greater density, where the convection would be greater and the bombardment less intense. Accordingly, a tube, *t*, was prepared, as illustrated in Fig. 23, which contained through the middle a very fine platinum wire, *w*. The tube was exhausted to a moderate degree, and it was found that when it was attached to the terminal of a high frequency coil the platinum wire *w* would indeed become incandescent in patches, as illustrated in Fig. 23. Later a number of these tubes with one or more wires were prepared, each showing this result. The effect was best noted when the striated discharge occurred in the tube, but was also produced when the striæ were not visible, showing that even then the gas in the tube was not of uniform density. The position of the striæ was generally such that the rarefactions corresponded to the places of incandescence or greater brightness on the wire *w*. But in a few instances it was noted that the bright

spots on the wire were covered by the dense parts of the striated discharge, as indicated by *l* in Fig. 23, though the effect was barely perceptible. This was explained in a plausible way by assuming that the convection was not widely different in the dense and rarefied places, and that the bombardment was greater on the dense places of the



FIG. 23.—CURIOUS INCANDESCENCE OF A WIRE.

striated discharge. It is, in fact, often observed in bulbs that under certain conditions a thin wire is brought to higher incandescence when the air is not too highly rarefied. This is the case when the potential of the coil is not high enough for the vacuum; but the result may be attributed to many different causes. In all cases this

curious phenomenon of incandescence disappears when the tube, or, rather, the wire, acquires throughout a uniform temperature.

Disregarding, now, the modifying effect of convection, there are, then, two distinct causes which determine the incandescence of a wire or filament with varying currents, that is, conduction current and bombardment. With steady currents we have to deal only with the former of these two causes, and the heating effect is a minimum, since the resistance is least to steady flow. When the current is a varying one, the resistance is greater, and hence the heating effect is increased. Thus, if the rate of change of the current is very great, the resistance may increase to such an extent that the filament is brought to incandescence with inappreciable currents, and we are able to take a short and thick block of carbon or other material and bring it to bright incandescence with a current incomparably smaller than that required to bring to the same degree of incandescence an ordinary thin lamp filament with a steady or low frequency current. This result is important, and illustrates how rapidly our views on these subjects are changing, and how quickly our field of knowledge is extending. In the art of incandescent lighting, to view this result in one aspect only, it has been commonly considered as an essential requirement for practical success, that the lamp filament should be thin and of high resistance. But now we know that the resistance to the steady flow of the filament does not mean anything; the filament might as well be short and thick; for if it be immersed in rarefied gas it will become incandescent by the passage of a small current. It all depends on the frequency and potential of the currents. We may conclude from this that it would be of advantage, so far as the lamp is considered, to

employ high frequencies for lighting, as they allow the use of short and thick filaments and smaller currents.

If a wire or filament be immersed in a homogeneous medium, all the heating is due to true conduction current; but if it be enclosed in an exhausted vessel, the conditions are entirely different. Here the gas begins to act, and the heating effect of the conduction current, as is shown in many experiments, may be very small compared with that of the bombardment. This is especially the case if the circuit is not closed and the potentials, of course, very high. Suppose a fine filament enclosed in an exhausted vessel be connected with one of its ends to the terminal of a high tension coil and with its other end to a large insulated plate. Though the circuit is not closed, the filament, as I have before shown, is brought to incandescence. If the frequency and potential be comparatively low, the filament is heated by the current passing *through* it. If the frequency and potential, and principally the latter, be increased, the insulated plate need be but very small, or may be done away with entirely, still the filament will become incandescent, practically all the heating being then due to the bombardment. A practical way of combining both the effects of conduction current and bombardment is illustrated in Fig. 24, in which an ordinary lamp is shown provided with a very thin filament, which has one of the ends of the latter connected to a shade serving the purpose of the insulated plate, and the other end to the terminal of a high tension source. It should not be thought that only rarefied gas is an important factor in the heating of a conductor by varying currents, but gas at ordinary pressure may become important, if the potential difference and frequency of the currents is excessive. On this subject I have already stated that when a conductor is fused by a stroke of

lightning, the current through it may be exceedingly small, not even sufficient to heat the conductor perceptibly were the latter immersed in a homogeneous medium.

From the preceding it is clear that when a conductor of high resistance is connected to the terminals of a

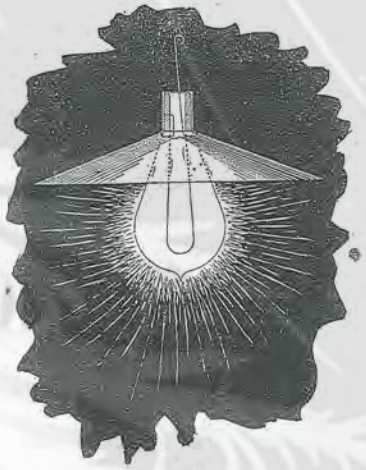


Fig. 24

FIG. 24.—UTILIZING THE HEATING EFFECT OF CONDUCTION CURRENT AND BOMBARDMENT.

source of high frequency currents of high potential, there may occur considerable dissipation of energy, principally on the ends of the conductor, in consequence of the action of the gas surrounding the conductor. Owing to this, the current through a section of the conductor at a point midway between its ends may be

much smaller than through a section near the ends. Furthermore, the current passes principally through the outer portions of the conductor, but this effect is to be distinguished from the skin effect as ordinarily interpreted, for the latter would or should occur also in a continuous incompressible medium. If a great many incandescent lamps are connected in series to a source of such currents, the lamps at the ends may burn brightly, whereas those in the middle may remain entirely dark. This is due principally to bombardment, as before stated. But even if the currents be steady, provided the difference of potential is very great, the lamps at the ends will burn more brightly than those in the middle. In such case, there is no rhythmical bombardment and the result is produced entirely by leakage. This leakage, or dissipation into space when the tension is high, is considerable when incandescent lamps are used, and still more considerable with arcs, for the latter act like flames. Generally, of course, the dissipation is much smaller with steady than with varying currents.

I have contrived an experiment which illustrates in an interesting manner the effect of lateral diffusion. If a very long tube is attached to the terminal of a high frequency coil, the luminosity is greatest near the terminal, and falls off gradually towards the remote end. This is more marked if the tube is narrow.

A small tube, about one-half inch in diameter and twelve inches long, Fig. 25, has one of its ends drawn out into a fine fibre, *f*, nearly three feet long. The tube is placed in a brass socket, T, which can be screwed on the terminal T_1 of the induction coil. The discharge passing through the tube first illuminates the bottom of the same, which is of comparatively large section; but through the long glass fibre the discharge cannot pass.

But gradually the rarefied gas inside becomes warmed and more conducting and the discharge spreads into the glass fibre. This spreading is so slow that it may take half a minute or more until the discharge has worked through up to the top of the glass fibre, then presenting the appearance of a strongly luminous thin thread. By adjusting the potential at the terminal the light may be



FIG. 25.—ILLUSTRATING LATERAL DIFFUSION.

made to travel upwards at any speed. Once, however, the glass fibre is heated, the discharge breaks through its entire length instantly. The interesting point to be noted is that the higher the frequency of the currents, or, in other words, the greater relatively the lateral dissipation, at a slower rate may the light be made to propagate through the fibre. This experiment is best per-

formed with a highly exhausted and freshly made tube. When the tube has been used for some time the experiment often fails. It is possible that the gradual and slow impairment of the vacuum is the cause. This slow propagation of the discharge through a very narrow glass tube corresponds exactly to the propagation of heat through a bar warmed at one end. The quicker the heat is carried away laterally the longer time it will take for the heat to warm the remote end. When the



FIG. 26.—INCANDESCENCE OF A SOLID.—ILLUSTRATING FOUR KINDS OF LIGHT EFFECTS PRODUCED BY HIGH FREQUENCY CURRENTS OF HIGH POTENTIAL.

current of a low frequency coil is passed through the fibre from end to end, then the lateral dissipation is small, and the discharge instantly breaks through, almost without exception.

After these experiments and observations, which have shown the importance of the discontinuity or atomic structure of the medium, and which will serve to explain, in a measure, at least, the nature of the four kinds of light effects producible with these currents I

may now give you an illustration of these effects. For the sake of interest, I may do this in a manner which to many of you might be novel. You have seen before that we may now convey the electric vibration to a body by means of a single wire or conductor of any kind. Since the human frame is conducting, I may convey the vibration through my body.

First, as in some previous experiments, I connect



FIG. 27.—PHOSPHORESCENCE.—ILLUSTRATING FOUR KINDS OF LIGHT EFFECTS PRODUCED BY HIGH FREQUENCY CURRENTS OF HIGH POTENTIAL.

my body with one of the terminals of a high-tension transformer and take in my hand an exhausted bulb which contains a small carbon button mounted upon a platinum wire leading to the outside of the bulb, and the button is rendered incandescent as soon as the transformer is set to work (Fig. 26). I may place a conducting shade on the bulb, which serves to intensify the action, but it is not necessary. Nor is it required that

the button should be in conducting connection with the hand through a wire leading through the glass, for sufficient energy may be transmitted through the glass itself by inductive action to render the button incandescent.

Next, I take a highly exhausted bulb containing a strongly phosphorescent body, above which is mounted a small plate of aluminum on a platinum wire leading to the outside, and the currents flowing through my body



FIG. 28.—INCANDESCENCE OR PHOSPHORESCENCE OF RAREFIED GAS.—ILLUSTRATING FOUR KINDS OF LIGHT EFFECTS PRODUCED BY HIGH FREQUENCY CURRENTS OF HIGH POTENTIAL.

excite intense phosphoresence in the bulb, Fig. 27. Next, again, I take in my hand a simple exhausted tube, and in the same manner the gas inside the tube is rendered highly incandescent or phosphorescent, Fig. 28. Finally, I may take in my hand a wire, bare or covered with thick insulation, it is quite immaterial; the electric vibration is so intense as to cover the wire with a luminous film, Fig. 29.

A few words must now be devoted to each of these phenomena. In the first place, I will consider the incandescence of a button or of a solid in general, and dwell upon some facts which apply equally to all these phenomena. It was pointed out before that when a thin conductor, such as a lamp filament, for instance, is connected with one of its ends to the terminal of a transformer of high tension, the filament is brought to



FIG. 29.—LUMINOSITY OF GAS AT ORDINARY PRESSURE.—ILLUSTRATING FOUR KINDS OF LIGHT EFFECTS PRODUCED BY HIGH FREQUENCY CURRENTS OF HIGH POTENTIAL.

incandescence partly by a conduction current and partly by bombardment. The shorter and thicker the filament, the more important becomes the latter; and finally, reducing the filament to a mere button, all the heating must practically be attributed to the bombardment. So in the experiment before shown, the button is rendered incandescent by the rhythmical impact of freely movable small bodies in the bulb. These bodies may be the

molecules of the residual gas, particles of dust, or lumps torn from the electrode; whatever they are, it is certain that the heating of the button is essentially connected with the pressure of such freely movable particles, or of atomic matter in general, in the bulb. The heating is the more intense the greater the number of impacts per second and the greater the energy of each impact. Yet the button would also be heated if it were connected to a source of a steady potential. In such a case electricity would be carried away from the button by the freely movable carriers or particles flying about, and the quantity of electricity thus carried away might be sufficient to bring the button to incandescence by its passage through the latter. But the bombardment could not be of great importance in such case. For this reason, it would require a comparatively very great supply of energy to the button to maintain it at incandescence with a steady potential. The higher the frequency of the electric impulses, the more economically can the button be maintained at incandescence. One of the chief reasons why this is so is, I believe, that with impulses of very high frequency there is less exchange of the freely movable carriers around the electrode, and this means that in the bulb the heated matter is better confined to the neighborhood of the button. If a double bulb, as illustrated in Fig. 30, be made, comprising a large globe, B, and a small one, *b*, each containing, as usual, a filament, *f*, mounted on a platinum wire, *w* and w_1, it is found that if the filaments *f f* be exactly alike it requires less energy to keep the filament in the globe *b* at a certain degree of incandescence than that in the large globe B. This is due to the confinement of the movable particles around the button. In this case, it is also ascertained that the filament in the small globe *b* is less deteriorated

when maintained a certain length of time at incandescence. This is a necessary consequence of the fact that the gas in the small bulb becomes strongly heated, and, therefore, a very good conductor, and less work is then performed on the button, since the bombardment becomes less intense as the conductivity of the gas increases. In this construction, of course, the small bulb becomes very hot, and when it reaches an elevated temperature, the convection and radiation on the outside increase. On another occasion I have shown bulbs in



FIG. 30.—SHOWING THE EFFECTS OF CONFINING THE GAS AROUND THE ELECTRODE.

which this drawback was largely avoided. In these instances a very small bulb, containing a refractory button, was mounted in a large globe, and the space between the walls of both was highly exhausted. The outer large globe remained comparatively cool in such constructions. When the large globe was on the pump and the vacuum between the walls maintained permanent by the continuous action of the pump, the outer globe would remain quite cold, while the button in the small bulb was kept at incandescence. But when the

seal was made, and the button in the small bulb maintained incandescent some length of time, the large globe, too, would become warmed. From this I conjecture that if vacuous space (as Prof. Dewar finds) cannot convey heat, it is so merely in virtue of our rapid motion through space, or, generally speaking, by the motion of the medium relatively to us, for a permanent condition could not be maintained without the medium being constantly renewed. A vacuum cannot, according

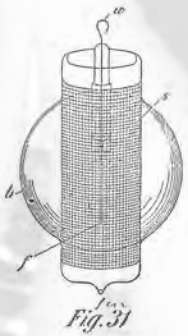


Fig. 31

FIG. 31.—SHOWING THE INEFFICIENCY OF A METAL SCREEN.

to all evidence, be permanently maintained around a hot body.

In these constructions, before mentioned, the small bulb inside would, at least in the first stages, prevent all bombardment against the outer, large globe. It occurred to me then to ascertain how a metal sieve would behave in this respect, and several bulbs, as illustrated in Fig. 31, were prepared for this purpose. In a globe *b*, was mounted a thin filament (or button), *f*, upon a platinum wire, *w*, passing through a glass stem

and leading to the outside of the globe. The filament *f* was surrounded by a metal sieve, *s*. It was found in experiments with such bulbs that a sieve with wide meshes apparently did not in the slightest affect the bombardment against the globe, *b*. When the vacuum was high the shadow of the sieve was clearly projected against the globe, and the latter would get hot in a short while. In some bulbs the sieve, *s*, was connected to a platinum wire sealed in the glass. When this wire was connected to the other terminal of the induction coil (the E. M. F. being kept low in this case), or to an insulated plate, the bombardment against the outer globe, *b*, was diminished. By taking a sieve with fine meshes the bombardment against the globe, *b*, was always diminished; but, even then, if the exhaustion was carried very far, and when the potential of the transformer was very high, the globe, *b*, would be bombarded and heated quickly, though no shadow of the sieve was visible, owing to the smallness of the meshes. But a glass tube or other continuous body mounted so as to surround the filament, did entirely cut off the bombardment, and for a while the outer globe, *b*, would remain perfectly cold. Of course, when the glass tube was sufficiently heated, the bombardment against the outer globe could be noted at once. The experiments with these bulbs seemed to show that the speeds of the projected molecules or particles must be considerable (though quite insignificant when compared with that of light), otherwise it would be difficult to understand how they could traverse a fine metal sieve without being affected, unless it were found that such small particles or atoms cannot be acted upon directly at measurable distances. In regard to the speed of the projected atoms, Lord Kelvin has recently estimated it at about one kilometre a second, or thereabouts, in an ordinary Crookes bulb. As the potentials

obtainable with a disruptive discharge coil are much higher than with ordinary coils, the speeds must, of course, be much greater when the bulbs are lighted from such a coil. Assuming the speed to be as high as five kilometres and uniform through the whole trajectory, as it should be in a very highly exhausted vessel, then if the alternate electrifications of the electrode would be of a frequency of five million, the greatest distance a particle could get away from the electrode would be one millimetre, and if it could be acted upon directly at that distance, the exchange of electrode matter or of the atoms would be very slow, and there would be practically no bombardment against the bulb. This, at least, should be so, if the action of an electrode upon the atoms of the residual gas would be such as upon electrified bodies which we can perceive. A hot body enclosed in an exhausted bulb produces always atomatic bombardment; but a hot body has no definite rhythm, for its molecules perform vibrations of all kinds.

If a bulb containing a button or filament be exhausted as high as is possible with the greatest care and by the use of the best artifices, it is often observed that the discharge cannot, at first, break through; but after some time, probably in consequence of some changes within the bulb, the discharge finally passes through and the button is rendered incandescent. In fact, it appears that the higher the degree of exhaustion, the easier is the incandescence produced. There seem to be no other causes to which the incandescence might be attributed in such case, except to the bombardment or similar action of the residual gas, or of particles of matter in general. But if the bulb be exhausted with the greatest care, can these play an important part? Assume the vacuum in the bulb to be tolerably perfect, the great interest then centres in the question: Is the

medium which pervades all space continuous or atomic? If atomic, then the heating of a conducting button or filament in an exhausted vessel might be due largely to ether bombardment, and then the heating of a conductor in general through which currents of high frequency or high potential are passed must be modified by the behavior of such medium; then, also, the skin effect, the apparent increase of the ohmic resistance, etc., admit, partially, at least, of a different explanation.

It is certainly more in accordance with many phenomena observed with high frequency currents to hold that all space is pervaded with free atoms, rather than to assume that it is devoid of these, and dark and cold, for so it must be, if filled with a continuous medium, since in such there can be neither heat nor light. Is, then, energy transmitted by independent carriers or by the vibration of a continuous medium? This important question is by no means as yet positively answered. But most of the effects which are here considered, especially the light effects, incandescence or phosphorescence, involve the presence of free atoms, and would be impossible without these.

In regard to the incandescence of a refractory button (or filament) in an exhausted receiver, which has been one of the subjects of this investigation, the chief experiences, which may serve as a guide in constructing such bulbs, may be summed up as follows: 1. The button should be as small as possible, spherical, of a smooth or polished surface and of refractory material, which withstands evaporation best. 2. The support of the button should be very thin and screened by an aluminum and mica sheet, as I have described on another occasion. 3. The exhaustion of the bulb should be as high as possible. 4. The frequency of the currents should be as high as practicable. 5. The currents should be of a harmonic

rise and fall, without sudden interruptions. 6. The heat should be confined to the button by enclosing the same in a small bulb, or otherwise. 7. The space between the walls of the small bulb and the outer globe should be highly exhausted.

Most of the considerations just considered which apply to the incandescence of a solid, may likewise be applied to phosphorescence. Indeed, in an exhausted vessel the phosphorescence is, as a rule, primarily excited by the powerful beating of the electrode stream of atoms against the phosphorescent body. Even in many cases where there is no evidence of such a bombardment, I think that phosphorescence is excited by violent impacts of atoms which are not necessarily thrown off from the electrode, but are acted upon from the same inductively, through the medium or through chains of other atoms. That mechanical shocks play an important part in exciting phosphorescence in a bulb, may be seen from the following experiment: If a bulb, constructed as that illustrated in Fig. 10, be taken, and exhausted with the greatest care so that the discharge cannot pass, the filament, *f*, acts by electrostatic induction upon the tube, *t*, and the latter is set in vibration. If the tube, *o*, be rather wide, about an inch or so, the filament may be so powerfully vibrated that whenever it hits the glass tube it excites phosphorescence. But the phosphorescence ceases when the filament comes to rest. The vibration can be arrested and again started by varying the frequency of the currents; namely, the filament has its own period of vibration, and if the frequency of the currents is such that there is resonance, it is set easily vibrating, though the potential of the currents be small. I have often observed that the filament in the bulb is destroyed by such mechanical resonance. The filament vibrates, as a rule, so rapidly that it cannot be seen, and

the experimenter may at first be mystified. When such an experiment as the one described is carefully performed, the potential of the currents need be extremely small, and for this reason I infer that the phosphorescence is then due to the mechanical shock of the filament against the glass, just as it is produced by striking a loaf of sugar with a knife. The mechanical shock produced by the projected atoms is easily noted when a bulb containing a button is grasped in the hand and the current turned on suddenly. I believe that a bulb could be shattered by observing the conditions of resonance.

In the experiment before cited it is, of course, open to say that the glass tube, upon coming in contract with the filament, retains a charge of a certain sign upon the point of contact. If, now, the filament again touches the glass at the same point while it is oppositely charged, the charges equalize under evolution of light. But nothing of importance would be gained by such an explanation. It is unquestionable that the initial charges given to the atoms or to the glass play some part in exciting phosphorescence. So, for instance, if a phosphorescent bulb be first excited by a high frequency coil by connecting it to one of the terminals of the latter, and the degree of luminosity noted; and then the bulb be highly charged from a Holtz machine by attaching it preferably to the positive terminal of the machine, it is found that when the bulb is again connected to the terminal of the high frequency coil, the phosphorescence is far more intense. On another occasion, I have considered the possibility of some phosphorescent phenomena in bulbs being produced by the incandescence of an infinitesimal layer on the surface of the phosphorescent body. Certainly, the impacts of the atoms are powerful enough to produce intense incandescence by the collisions, since they bring quickly to a high temperature

a body of considerable bulk. If any such effect exists, then the best appliance which we know so far, for producing phosphorescence in a bulb, is a disruptive discharge coil giving an enormous potential with but few fundamental discharges, say, 25-30 per second, just enough to produce a continuous impression upon the eye. It is a fact that such a coil excites phosphorescence under most any condition and at all degrees of exhaustion, and I have observed effects which appear to be due to phosphorescence even at ordinary pressures of the atmosphere, when the potentials are extremely high. But if phosphorescent light is produced by the equalization of charges of electrified atoms (whatever this may mean ultimately), then the higher the frequency of the impulses or alternate electrifications, the more economical will be the light production. It is a long known and noteworthy fact that all the phosphorescent bodies are poor conductors of electricity and heat, and that all bodies cease to emit prosphorescent light when they are brought to a certain temperature. Conductors, on the contrary, do not possess this quality. There are but few exceptions to the rule. Carbon is one of them. Becquerel noted that carbon phosphoresces at a certain elevated temperature preceding the dark red. This phenomenon may be easily observed in bulbs provided with a rather large carbon electrode (say a sphere of six millimetres diameter). If the current is turned on after a few seconds, a snow white film covers the electrode just before it gets dark red. Similar effects are noted with other conducting bodies, but many scientific men will probably not attribute them to true phosphorescence. Whether true incandescence has anything to do with phosphorescence, excited by atomic impact or mechanical shocks, still remains to be decided; but it is a fact that all conditions which tend

to localize and increase the heating effect at the point of impact, are almost invariably the most favorable for the production of phosphorescence. So, if the electrode be very small, which is equivalent to saying, in general, that the electric density is great; if the potential be high, and if the gas be highly rarefied—all of which things imply high speed of the projected atoms or matter, and, consequently, violent impacts—the phosphorescence is very intense. If a bulb, provided with a large and small electrode, be attached to the terminal of an induction coil, the small electrode excites phosphorescence, while the large one may not do so because of the smaller electric density, and hence smaller speed of the atoms. A bulb provided with a large electrode may be grasped with the hand while the electrode is connected to the terminal of the coil and it may not phosphoresce; but if, instead of grasping the bulb with the hand, the same be touched with a pointed wire, the phosphorescence at once spreads through the bulb, because of the great density at the point of contact. With low frequencies it seems that gases of great atomic weight excite more intense phosphorescence than those of smaller weight, as, for instance, hydrogen. With high frequencies the observations are not sufficiently reliable to draw a conclusion. Oxygen, as is well known, produces exceptionally strong effects, which may be in part due to chemical action. A bulb with hydrogen residue seems to be most easily excited. Electrodes which are most easily deteriorated produce more intense phosphorescence in bulbs; but the condition is not permanent, because of the impairing of the vacuum and the deposition of the electrode matter upon the phosphorescent surfaces. Some liquids, as oils, for instance, produce magnificent effects of phosphorescence (or fluorescence?), but they last only a few seconds. So if a bulb have a trace of oil on the walls,

and the current is turned on, the phosphorescence only persists for a few moments, until the oil is carried away. Of all bodies so far tried, sulphide of zinc seems to be the most susceptible to phosphorescence. Some samples, obtained through the kindness of Prof. Henry, in Paris, were employed in many of these bulbs. One of the defects of this sulphide is that it loses its quality of emitting light when brought to a temperature which is by no means high. It can, therefore, be used only for feeble intensities. An observation which might deserve notice is that when violently bombarded from an aluminum electrode it assumes a black color; but, singularly enough, it returns to the original condition when it cools down.

The most important fact arrived at in pursuing investigations in this direction is, that in all cases it is necessary, in order to excite phosphorescence with a minimum amount of energy, to observe certain conditions; namely, there is always, no matter what the frequency of the currents, degree of exhaustion and character of the bodies in the bulb, a certain potential (assuming the bulb excited from one terminal) or potential difference (assuming the bulb to be excited with both terminals) which produces the most economical result. If the potential be increased, considerable energy may be wasted without producing any more light; and if it be diminished, then, again, the light production is not so economical. The exact condition under which the best result is obtained seems to depend on many things of a different nature, and it is to be yet investigated by other experimenters; but it will certainly have to be observed when such phosphorescent bulbs are operated, if the best results are to be attained.

Coming now to the most interesting of these phenomena, the incandescence or phosphorescence of gases

at low pressure or at the ordinary pressure of the atmosphere, we must seek the explanation of these phenomena in the same primary causes; that is, in shocks or impacts of the atoms. Just as molecules or atoms beating upon a solid body excite phosphorescence in the same, or render it incandescent, so when colliding among themselves they produce similar phenomena. But this is a very insufficient explanation, and concerns only the crude mechanism. Light is produced by vibrations, which go on at a rate almost inconceivable. If we compute from the energy contained in the form of known radiations in a definite space the force which is necessary to set up such rapid vibrations, we find that though the density of the ether be incomparably smaller than that of any body we know, even hydrogen, the force is something surpassing comprehension. What is this force, which, in mechanical measure, may amount to thousands of tons per square inch? It is electrostatic force in the light of modern views. It is impossible to conceive how a body of measurable dimensions could be charged to so high a potential that the force would be sufficient to produce these vibrations. Long before any such charge could be imparted to the body it would be shattered into atoms. The sun emits light and heat, and so does an ordinary flame or incandescent filament; but in neither of these can the force be accounted for if it be assumed that it is associated with the body as a whole. Only in one way may we account for it, namely, by identifying it with the atom. An atom is so small that if it be charged by coming in contact with an electrified body, and the charge be assumed to follow the same law as in the case of bodies of measurable dimensions, it must retain a quantity of electricity which is fully capable of accounting for these forces and tremendous rates of vibration.

But the atom behaves singularly in this respect; it always takes the same "charge."

It is very likely that resonant vibration plays a most important part in all manifestations of energy in nature. Throughout space all matter is vibrating, and all rates of vibration are represented, from the lowest musical note to the highest pitch of the chemical rays; hence an atom, or complex of atoms, no matter what its period, must find a vibration with which it is in resonance. When we consider the enormous rapidity of the light vibrations, we realize the impossibility of producing such vibrations directly with any apparatus of measurable dimensions, and we are driven to the only possible means of attaining the object of setting up waves of light by electrical means and economically; that is, to affect the molecules or atoms of a gas, to cause them to collide and vibrate. We then must ask ourselves: How can free molecules or atoms be affected?

It is a fact that they can be affected by electrostatic force, as is apparent in many of these experiments. By varying the electrostatic force we can agitate the atoms, and cause them to collide under evolution of heat and light. It is not demonstrated beyond boubt that we can affect them otherwise. If a luminous discharge is produced in a closed exhausted tube, do the atoms arrange themselves in obedience to any other but to electrostatic force acting in straight lines from atom to atom? Only recently I investigated the mutual action between two circuits with extreme rates of vibration. When a battery of a few jars (*c c c c*, Fig. 32) is discharged through a primary, P, of low resistance (the connections being as illustrated in Figs. 19*a*, 19*b*, and 19*c*), and the frequency of vibration be many million, there are great differences of potential between points on the primary not more than a few inches apart. These differences may

be 10,000 volts per inch, if not more, taking the maximum value of the electromotive force. The secondary, *s*, is therefore acted upon by electrostatic induction, which is, in such extreme cases, of much greater importance than the electro-dynamic. To such sudden impulses the primary, as well as the secondary, are poor conductors, and therefore great differences of potential may be produced by electrostatic induction between adjacent points on the secondary. Then sparks may jump between the wires and streamers become visible in the dark, if the



Fig. 32

FIG. 32.—ELECTROSTATIC ACTION BETWEEN PRIMARY AND SECONDARY, WITH EXTREMELY HIGH FREQUENCIES.

light of the discharge through the spark gap *d d* be carefully excluded. If, now, we substitute a closed vacuum tube for the metallic secondary *s*, the differences of potential produced in the tube by electrostatic induction from the primary are fully sufficient to excite portions of it; but as the points of certain differences of potential on the primary are not fixed, but are generally constantly changing in position, a luminous band is produced in the tube, apparently not touching the glass, as it should if the points of maximum and mini-

mum differences of potential were fixed on the primary. I do not exclude the possibility of such a tube being excited only by electro-dynamic induction, for very able physicists hold this view; but, in my opinion, there is as yet no positive proof given that atoms of a gas in a closed tube may arrange themselves in chains under the action of an electromotive impulse produced by electro-dynamic induction in the tube. I have been unable so far to produce striæ in a tube, however long, and at whatever degree of exhaustion; that is, striæ at right angles to the supposed direction of the discharge or the axis of the tube; but I have distinctly observed in a large bulb, in which a wide luminous band was produced by passing a discharge of a battery through a wire surrounding the bulb, a circle of feeble luminosity between two luminous bands, one of which was more intense than the other. Furthermore, with my present experience, I do not think that such a gas discharge in a closed tube can vibrate; that is, vibrate as a whole. I am convinced that no discharge through a gas can vibrate. The atoms of a gas behave very curiously in respect to sudden electric impulses. The gas does not seem to possess any appreciable inertia to such impulses; for it is a fact, that the higher the frequency of the impulses, with the greater freedom does the discharge pass through the gas. If the gas possesses no inertia, then it cannot vibrate, for some inertia is necessary for the free vibration. I conclude from this that if a lightning discharge occurs between two clouds, there can be no oscillation, such as would be expected, considering the capacity of the clouds. But if the lightning discharge strike the earth, there is always vibration—in the earth, but not in the cloud. In a gas discharge each atom vibrates at its own rate, but there is no vibration of the conducting gaseous mass as a whole. This is an important consideration in the great problem of producing light economically, for it teaches us that to reach this result we must use impulses of very high frequency and necessarily also of high potential. It is a fact that oxygen produces a more intense light in a tube. It is because oxygen atoms possess some inertia and the vibration does not die out instantly? But then nitrogen should be as good as, and chlorine and vapors of many other bodies much better than, oxygen, unless the magnetic properties of the latter enter prominently into play. Or is the process in the tube of an electrolytic nature? Many observations certainly speak for it, the most important being, that matter is always carried away from the electrodes and the vacuum in a bulb cannot be permanently maintained. If such process takes place in reality, then, again, must we take refuge to high frequencies, for with such, electrolytic action should be reduced to a minimum, if not rendered entirely impossible. It is an undeniable fact that with very high frequencies, provided the impulses be of a harmonic nature, like those obtained from an alternator, there is less deterioration and the vacua are more permanent. With disruptive discharge coils there are sudden rises of potential and the vacua are more quickly impaired, for the electrodes are deteriorated in a very short time. It was observed in some large tubes, which were provided with heavy carbon blocks B B_1, connected to platinum wires w w_1 (as illustrated in Fig. 33), and which were employed in experiments with the disruptive discharge instead of the ordinary air gap, that the carbon particles, under the action of the powerful magnetic field in which the tube was placed, were deposited in regular fine lines in the middle of the tube, as illustrated. These lines were attributed to the deflection or distortion of the discharge by the magnetic field; but why the deposit

occurred principally where the field was most intense did not appear quite clear. A fact of interest, likewise noted, was that the presence of a strong magnetic field increases the deterioration of the electrodes, probably by reason of the rapid interruptions it produces, whereby there is actually a higher electromotive force maintained between the electrodes.

Much would remain to be said about the luminous effects produced in gases at low or ordinary pressures. With the present experiences before us we cannot say that the essential nature of these charming phenomena is sufficiently known. But investigations in this direc-



Fig. 33

Fig. 33.—Carbon Deposit in Tube in a Magnetic Field.

tion are being pushed with exceptional ardor. Every line of scientific pursuit has its fascinations; but electrical investigation appears to possess a peculiar attraction, for there is no experiment or observation of any kind in the domain of this wonderful science which would not forcibly appeal to us. Yet to me it seems that of all the many marvelous things we observe, a vacuum tube, excited by an electric impulse from a distance source, bursting forth out of the darkness and illuminating the room with its beautiful light, is as lovely a phenomenon as can greet our eyes. More interesting still it appears when, reducing the fundamental discharges across the

gap to a very small number, and waving the tube about, we produce all kinds of designs in luminous lines. So, by way of amusement, I take a straight long tube, or a square one, or a square attached to a straight tube, and by whirling them about in the hand, I imitate the spokes

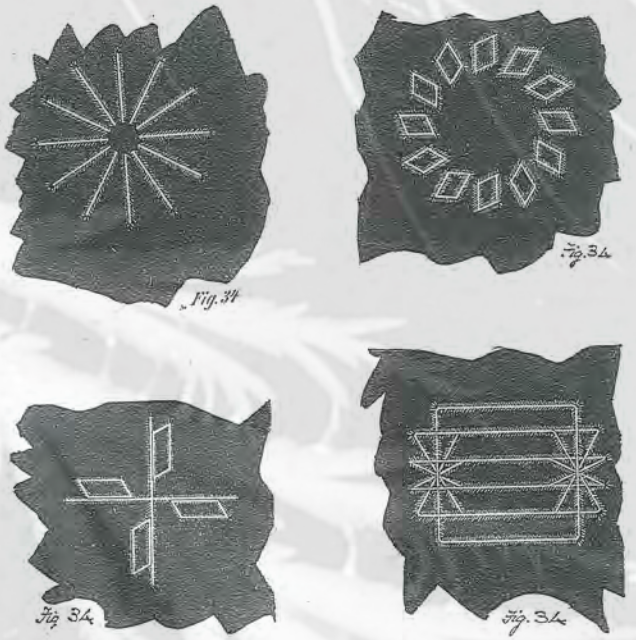


Fig. 34.—Spoke Wheel, Drum Winding, Alternate Motor Winding, Ring Winding—Some of the Designs Produced by Intermittent Discharges.

of a wheel, a Gramme winding, a drum winding, an alternate current motor winding, etc. (Fig. 34). Viewed from a distance the effect is weak and much of its beauty is lost; but being near or holding the tube in the hand one cannot resist its charm.

In presenting these insignificant results I have not attempted to arrange and co-ordinate them as would be proper in a strictly scientific investigation, in which every succeeding result should be a logical sequence of the preceding, so that it might be guessed in advance by the careful reader or attentive listener. I have preferred to concentrate my energies chiefly upon advancing novel facts or ideas which might serve as suggestions to others, and this may serve as an excuse for the lack of harmony. The explanations of the phenomena have been given in good faith and in the spirit of a student prepared to find that they admit of a better interpretation. There can be no great harm in a student taking an erroneous view, but when great minds err, the world must dearly pay for their mistakes.

Oct. 24, 1967 N. J. TRBOJEVICH 3,349,002

NUCLEAR REACTOR

Filed March 28, 1958

FIG.1.

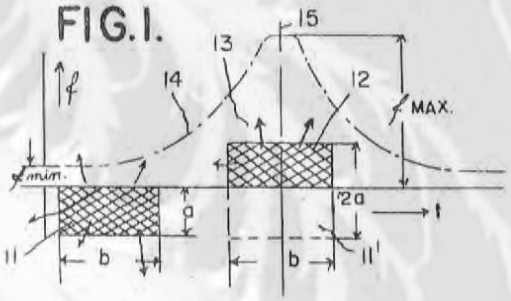


FIG.2.

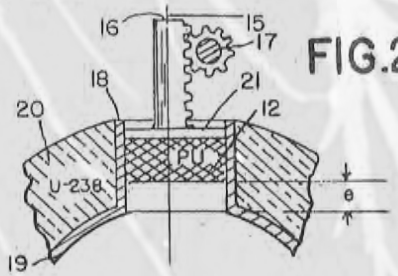


FIG.3.

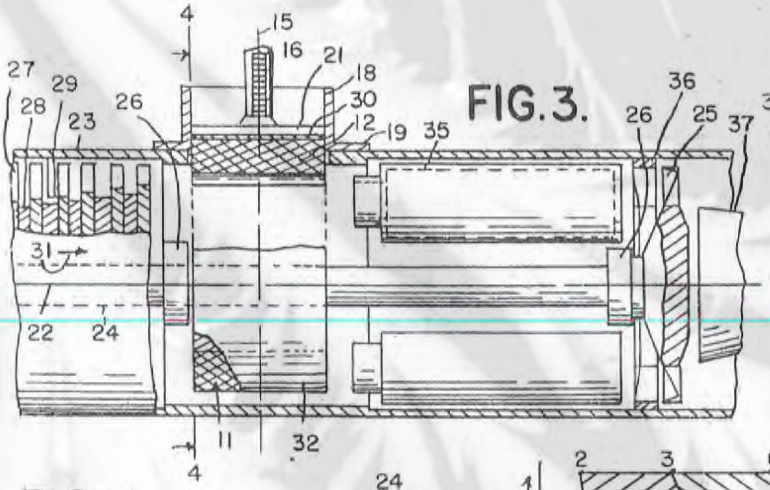


FIG.4.

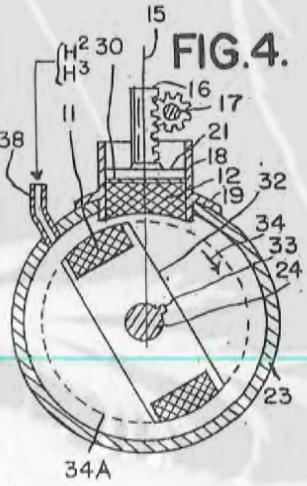


FIG.7.

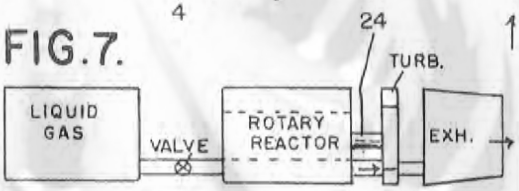
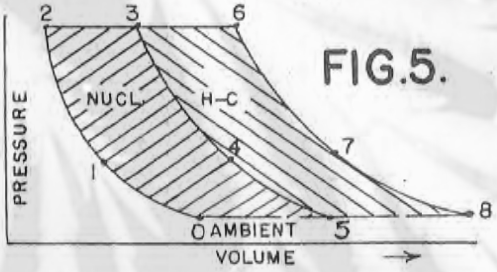


FIG.5.



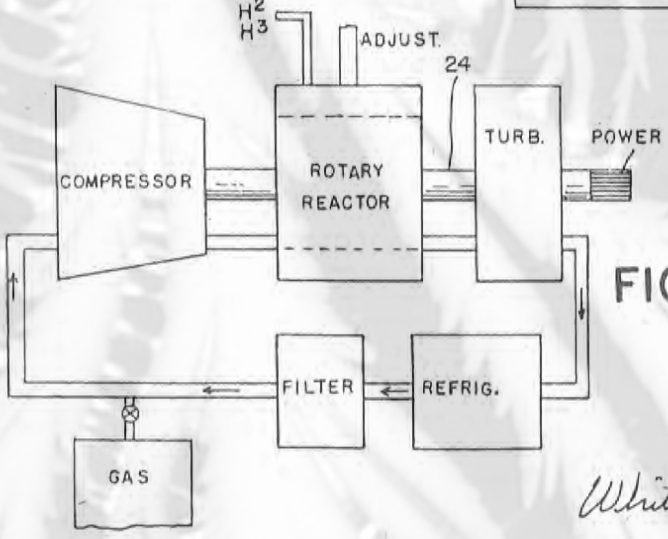


FIG.6.

INVENTOR.
NIKOLA J. TRBOJEVICH

BY
Whittemore, Hulbert & Belknap
ATTORNEYS

A NEW THEORY ON ETHER AND MASS-ENERGY RELATIONS
By Nikola J. Trbojevich (Nicholas J. Terbo) (1886-1973), September 24, 1959

To: Dr. James Corum and Dr. Jasmina Vujic: 30 October 2000

From: William H. Terbo

Enclosed is a copy of my father's space-time physics theory that he developed over forty years ago. I had set it aside several months ago to send to Jim, he being one of the few people I know who has both the knowledge of the field and the (hoped for) willingness to review and comment on what is to me is a fairly esoteric subject. When I mentioned the work to Jasmina during my October 14-17 visit to UC Berkeley to speak to her Tesla history course, she asked for a copy for review. It was the spark I needed to get this effort moving.

I've reread the work today. The words are easy, but the concepts aren't so easy for me so far removed from my physics education. (It put me in mind of reading Stephen Hawking's "A Brief History Of Time." It took me almost two transcontinental air trips to momentarily absorb his less than 200 pages of similar material.) A lot of credit must go to my college friend and tournament bridge partner, the late Burt Randolph, who spent many weeks with my father acting as a "devil's advocate" to force dad to defend his theory, and then managing the organization of the work into its present readable form. (Burt got his doctorate in Mechanical Engineering at Purdue while I was getting my bachelor's.)

This theory is a pretty substantial departure for my father. Most of his previous work was in the invention of various gears, most notably the basic patent on the Hypoid gear in 1923. It was the first gear design using the application of advanced mathematics. (Tesla called my dad "my nephew, the mathematician.") This theory was pretty aggressive considering the year, 1959, and my father's age, 73. Research was complicated as the publishing of much new nuclear science technology was restricted for security reasons, so more credit is due for dad's creativity. I know he spent at least seven or eight years developing his knowledge in the field.

I would appreciate a couple of very brief comments done at your leisure. I really have only two questions that need resolution for my satisfaction. First, was my dad really on to something important, or was it too much of a leap? Second, is the theory good but outdated, or overtaken by current science?

You may distribute this material to your academic colleagues if you wish.

Thanks,

Bill WHT/njtkl

FOREWORD

This paper deals with the structure of the universe, the nature of space and time and the mass-energy relations.

The subject matter is of the kind which is not readily approachable either by laboratory experiments or mathematics. It is the product of free invention.

Nevertheless, the paper contains several ideas relating to nuclear and thermo-nuclear energies, the theories of quanta and relativity, which may have important practical consequences.

The writer spent a lifetime as a free-lance engineer and inventor. It is another object of this paper to demonstrate that the art of invention, when pursued purposively, diligently and professionally, may easily become a most valuable tool in scientific research.

I wish to express my particular thanks to Dr. B. W. Randolph who has read the first two drafts of this paper and has offered a number of valuable suggestions in this connection.

Nikola J. Trbojevich

September 24, 1959

Santa Monica, Calif.

A NEW THEORY ON ETHER AND MASS-ENERGY RELATIONS

(Time and space are discontinuous and consist of indivisible quanta)

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1. Discontinuity everywhere

It is well known that matter, energy, electric charges and actions are all discontinuous and appear as quanta, i.e., in small and indivisible units or bundles.

It is the object of this paper to show that the quantum principle extends throughout the world and embraces space, time, inertia, gravitation and everything else.

The great German philosopher Kant wrote 200 years ago: "A body consists of particles, a motion consists of motions, space consists of spaces and time consists of moments. All physical processes are staccato." This uncanny prediction is held here to be true, as it will be presently shown.

The so-called space will hereinafter be referred to by the term "ether."

2. There Must be an Ether

Ever since Newton, through Maxwell, Hertz, Lorentz and Einstein, there was a profound belief among scientists that action at a distance among material particles was utterly impossible and what is sometimes called the "empty space", must possess some sort of metric or structure which enables the particles to cooperate by means of fields.

Einstein called ether "a four-dimensional space-time continuum", but occasionally he would use the word ether, as in this quotation: "Space without ether is unthinkable for in such a space there would be no propagation of light".

The difficulty in defining of what ether is, or should be, is found in the fact that ether must do so many different things at the same time. It is non-material and yet it interacts with matter. It possesses no inertia and is not subject to gravitation and yet, it is inextricably linked with those two phenomena, and so on.

Michelson-Morley experiments have definitely shown that there was no ether drag. Light, which was supposed at that time to be an entirely ethereal phenomenon showed a most baffling discrepancy in that its velocity was constant whether it was measured in the direction of earth's motion or against it. This led to the well known theory of relativity about which Dr. Soddy once wrote to the effect "Einstein's principle of mass and energy equivalence is a profound truth and a fundamental law of nature which, however, was derived by faulty logic."

In this discussion we shall attempt to revise and amend radically the theories of light and relativity.

D'Abro said once that in Einstein the old-fashioned ether was "reinstated in the guise of a metrical field of the space-time". He further thought that Einstein's geodesic lines must be "a rarified form of matter or a reality of a category different from matter".

Newton believed in absolute space and time, but he did not believe that what he called the "brute masses" could possibly act one upon the other without an intervening medium. Heitler thought that the discontinuous happenings and jumps in atoms "might be caused by some outside influence".

Born said: "Ether must be something very different from ordinary terrestrial substances".

De Bothezat conjectured: "maybe ether is just an even mesh of threadlike subelectrons".

Weyl said: "The centrifugal and other inertial forces take their origin from the metrical structure of the world".

Dantzig said: "Gravitation is not affected by the velocities of bodies". We now conclude: Ether must contain large amounts of energy and/or matter of a sub-gravitational and sub-inertial character which vibrates on the principle of standing waves such as are found in cavity or black body radiation.

The above statement implies that both inertia and gravitation are quantized, i.e., are not infinitely divisible. Both possess a lower limit, just like electric charges or quanta of action, below which they cannot go. This is the novel aspect of this theory and it will be further discussed in this paper.

3. The Structure of Ether

The structures of matter and ether must be complementary of each other. Both must consist of two congruous networks of equispaced discontinuities. It is only in this manner conceivable how it is possible for bodies to move through ether without a drag.

From this it follows that time and space must also be discontinuous and must consist of quanta.

These statements when proved, may become factors of considerable importance not only in physics but also in engineering. Once we can establish a one-to-one correspondence between the structures of ether and matter, we may determine the structure of ether from the structure of matter or conversely. Obviously this "double-check" should be useful in many applications, as for instance in comprehending the structures of various nuclei. The principle should also make it possible to verify this theory by laboratory experiments.

It is interesting to note that the structure of ether may be determined by calculation only. It is possible to do so, once the principle of complementarity between space and matter has been accepted.

Another interesting application of the principle of complementarity is that it explains the universal "tremor", as Dirac called it, which pervades all the matter in the universe.

As is well known, all particles of matter move, rotate or vibrate forever without any consumption of energy and without any visible cause.

This is due to the vibration of ether. According to this theory ether is a field of standing and monochromatic waves uniformly extending throughout the universe.

The matter particles act as impurities imbedded in the pristine cleanliness of ether and are floating around in its meshes in very much the same manner as the colored pollen grains move about in water in the Brownian effect.

Ether particularly resembles the cavity radiation in Kirchhoff's black body furnace in all respects except that the radiation field is of an incomparably higher frequency and is strictly monochromatic.

Dirac's "tremor" was noticed by many other physicists.

Gamow called it "the restless universe".

De Broglie said once: "the question may be asked whether our customary ideas of time and space which we believe to be a perfectly continuous framework, were genuinely valid".

Zeno thought that time was discontinuous just like matter and was composed of "moments". Born referred to it as the "inexplicable stability of atoms".

Jeans said "either causality or continuity must be renounced". He further said: "Bohr jumps prove that there is no continuity in space and time". F. A. Lindemann stated that "if we postulate that the space and time are not continuous, the whole quantum theory follows naturally as a consequence". Soddy said: "zero point energy proves that the state of rest in nature is unthinkable." Heisenberg and other scientists at one time seriously considered the discontinuity of space and time. The units or quanta of space and time were named "hodon" and "chronon", respectively.

We shall now proceed with the calculation of the space and time quanta.

4. Calculation of the Space and Time Quanta

It was stated in previous paragraphs that the principle of complementarity will enable us to determine the structure of ether by calculation only.

According to this theory, the meshes of ether must correspond to the meshes of matter exactly.

From this it follows that nature cannot build a particle larger in diameter than a single mesh or cubicle of space. This defines the diameter of the space quantum d.

Mosharaffa once suggested that matter may be nothing but "congealed radiation". In the light of this theory, Mosharaffa's statement is true. This gives us an interesting view on the possible origin of the universe. As the Bible says: "fiat lux", ether was the first and matter the second, to appear on the scene of creation.

Thus, the universe may be conceived as being a large mass of vibrating photon gas, which is energy, in which a very small part consists of impurities, which is matter, resulting from the partial condensation of that gas. According to an estimate made by Einstein and others, the solid matter in the vast ocean of ether, i. e., the photon gas, amounts to only about one part in 10^{30}.

It will be noted that while this theory is completely strange to all our perceptions yet, mathematically it is ridiculously simple.

This will come as a welcome relief to many of us who cannot find sufficient time to enthuse about tensors, Christoffel and the Italian calculus.

It is now possible greatly to simplify such abstruse doctrines as quantum mechanics, the theory of relativity, the relativistic mass increase, the dual aspect of light and many other difficult problems.

The explanation is that the theory is self-complete and explains the universe as if the universe were only a very large machine having a limited number of operations, all of which are strange, but not too complicated when compared with the tremendous complexity in toto.

As already stated, the wavelength of ether is equal to d which is also the diameter of the largest solid particle which nature can build.

It is assumed that the said largest particles are the neutron and proton, or, more correctly, the solid cores of the said nucleons.

A neutron or a proton then consists of a solid core which is assumedly spinning and is therefore surrounded by a photonic fuzz, probably a modification of the de Broglie wave. The mass of this fuzz is very small and may be considered as negligible in this calculation.

Hence the mass of the said solid core of a nucleon is taken to be very nearly equal to the atomic mass unit:

$$m = 1.66 \times 10^{-24} \text{ gram}$$

The velocity of light $c = 3 \times 10^{10}$ cm/sec

The Planck constant $h = 6.6 \times 10^{27}$ ergsec

Let N denote the frequency of ether, then $\frac{1}{N}$ will be the time quantum.

$$\text{velocity of light} = \frac{\text{space quantum}}{\text{time quantum}} = Nd \qquad 1)$$

Note than both quanta may be obtained entirely by calculation, i.e., without any recourse to experiments or laboratory measurement.

All that is required is to know the three great constants of nature namely, the velocity of light c, the quantum of action h, and the atomic mass unit m.

The above three constants comprise among them the entire structure of the universe.

The calculation may now proceed along three different formulas, respectively belonging to Planck - Einstein, de Broglie and Bertrand Russel.

All three of these formulas express the same thing, that is, the equivalence of mass and energy and they can be deduced one from another.

Einstein - Planck: $mc^2 = h N$ 2)

De Broglie: $d = \frac{h}{mc}$ 3)

Russel: Energy x time of one vibration = action 4)

Regarding the above Russel formula, it may be pointed out that Russel was the first, we believe, who pointed out that in the theory of quanta it is the action and not the energy of radiation which is of prime importance. Said Lord Russel: "Perhaps a theory giving more prominence to action may be possible and may facilitate a simpler statement of the quantum principle". In this theory, we found the above suggestion very productive as it fits into this scheme perfectly.

The maximum momentum which nature can produce in a single particle is the product of the mass of the said heaviest particle and the maximum velocity, the velocity of light.

In Russel's formula, equation (4), the energy may be denoted with $E = mc^2$ and the time of one vibration is the time quantum $\frac{1}{N}$. In de Broglie's equation (3) the minimum wave length is the space quantum d. Hence, we write:

$$E \times \frac{1}{N} = h \qquad 5)$$

$$\text{from which } N = \frac{mc^2}{h} = \frac{(1.66 \times 10^{-24})(9 \times 10^{20})}{6.6 \times 10^{-27}} = 2.3 \times 10^{23} \text{ per sec}$$

Hence, the maximum frequency (or action) which nature can produce and which is numerically equal to the frequency and also the action of ether is:

$$N = 2.3 \times 10^{23} \text{ per sec} \qquad 6)$$

The time quantum is the reciprocal of frequency:

$$\frac{1}{N} = 4.4 \times 10^{-24} \text{ sec} \qquad 7)$$

The space quantum d is equal to:

$$d = \frac{C}{N} = 3 \times 10^{10} \times 4.4 \times 10^{-24} = 1.32 \times 10^{-13} \text{cm} \qquad 8)$$

Noting that the space quantum $\underline{d}$ is also the diameter of the largest solid particle, the maximum specific gravity or density of the primordial matter is:

$$\text{Max. density } \gamma = 1.38 \times 10^{15} \text{ gram/cm}^3 \qquad 9)$$

The results so far obtained are:

space quantum	$d = 1.32 \times 10^{-13}$ cm
time quantum	$\frac{1}{N} = 4.4 \times 10^{-24}$ sec
max. frequency	$N = 2.3 \times 10^{23}$ per sec
max. density	$\gamma = 1.38 \times 10^{15}$ gram/cm^3

5. The Theory of Unit Photons

The theory of unit photons is probably the most speculative and controversial part of this paper. However, this concept explains so many things which could not be explained before that we believe the idea is fundamentally correct.

Einstein wrote once: "Matter is where the concentration of energy is great and field is where the concentration is small".

We already mentioned Mosharaffa who suggested that "matter is nothing but congealed radiation". A Soviet scientist, J. Frenkel, voiced a similar opinion when he wrote: "Matter is a collection of interpenetrating dynamical fields, electromagnetic and nuclear, with material particles and bodies forming nodal points".

How can we explain the true nature of a field? It is to be noted that ether, as herein defined, is also a field. Fields are not subject to gravity, they possess no inertia and yet, they are capable of interacting with matter. How can that be? The answer is:

There are entities in nature which contain sub-gravitational and sub-inertial matter. Fields are such entities.

When Einstein analyzed the photoelectric effect, he conceived the idea and the word "photon".

We usually speak of energy of the light quanta. However, it was Russel, previously quoted, who first pointed out that in radiation it is the action and not the energy which is of prime significance. Action is a product of energy and time in which time represents the duration of a single impulse. Obviously then, the shorter the pulse, the higher the quality of action during a given time interval. In this sense, action replaces the concept of temperature in radiation and leads to the application of the thermodynamical law of entropy in radiation.

In the preceding paragraphs, we postulated the geometrical structure of ether. It appears that both space and time are atomicized. Space is divided into a network of small cubes, or possibly spheres, each having the edge, or the diameter, equal

to 1.32×10^{-13} cm, while time is divided into moments, each moment lasting 4.4×10^{-24} sec. In the deduction stated, only three well known constants of nature were used. The most important of the three seems to be Planck's unit of action $\underline{h} = 6.6 \times 10^{-27}$ ergsec.

It is, of course, to be understood that the quantized space-time concept applies only to the inside of the universe which is considered finite. What lies beyond, it is impossible for us to know or even imagine.

The fact remains that the concepts of space and time are meaningless and wholly mathematical, unless something is happening in them. Thus, we must ask ourselves the question: Why should these two entities be quantized and how?

The only consistent answer is: The space must be full of energy. As Max Born once remarked: "A vibration is impossible unless there is something to vibrate with". That "something" consists of unit photons. Inasmuch as energy and matter are equivalent and convertible one into the other, it follows that space must also contain matter.

Just because matter and energy embodied in ether as defined here are not detectable by any of our instruments or senses and that they are not subject either to gravitation or inertia, it is no proof that they do not exist. It is readily imaginable that our bodies and instruments are completely transparent with respect to ether. The presence of ether is noticeable only in a round-about way, e.g., by means of centrifugal forces and the resistance of bodies to various types of acceleration and changes of momentum.

It is also equally imaginable that certain smallest particles, the unit photons, are able to escape the meshes of gravitation and inertia, providing however that they are suitably dispersed over the required number of space quanta.

We shall now calculate the mass of the unit photon and denote it with the symbol μ.

The largest energy quantum which nature can produce was already calculated:

$$E_{max} = mc^2 = hN = 1.5 \times 10^{-3} \text{ erg} \quad (10)$$

in which m is the mass of the solid core of the nucleon and N is the frequency of vibration of ether.

We assume that there also exists a minimum quantum of energy in universe.

After Planck's definition, it may be assumed that the quantum of action h is indivisible and that no smaller quantum than h can be found in nature. Since h contains no fractions, nature can only form a series of following energy quanta:

$$h/sec,\ 2h/sec,\ 3h/sec,\ \ldots\ldots\ldots\ hNerg \qquad (11)$$

That is, there are $N = 2.3 \times 10^{23}$ possible energy quanta in nature, ranging from a minimum $E_{min} = h/sec$ to a maximum $E_{max} = hNerg$. (12)

Similarly, there are 2.3×10^{23} possible action quanta. The action series is of the following form:

$$h,\ 2h,\ 3h,\ \ldots\ldots\ldots\ hN' \text{ ergsec} \qquad (13)$$

Note that in the above action series N' is no longer a frequency, it is only a number.

We are now in a position to define the minimum energy and action quanta or units.

$$\text{Minimum energy} = \mu c^2 = h/sec = 6.6 \times 10^{-27} \text{ erg} \qquad (14)$$

$$\text{Minimum action} = h = 6.6 \times 10^{-27} \text{ ergsec} \qquad (15)$$

From this the mass μ of the unit photon is

$$\mu = \frac{m}{N'} = \frac{1.66 \times 10^{-24}}{2.3 \times 10^{23}} = 7.2 \times 10^{-48} \text{ gram} \qquad (16)$$

Ether contains one unit photon in each space cubicle or quantum.

All matter is composed of unit photons in various degrees of concentration. For example, the solid cores of nucleons comprise 2.3×10^{23} unit photons each while the electrons consist of only 1.23×10^{20} unit photons each and each occupies a single space quantum.

The density of matter $\rho = 1.38 \times 10^{15}$ gram/cm^3, as already stated. Thus, a cm^3 of the primordial matter would weigh upwards of a billion tons!

Further calculations show the following dimensions of the unit photon:

mass	$= 7.2 \times 10^{-48}$ gram
diameter	$= 2.7 \times 10^{-25}$ cm
cross section	$= 5.7 \times 10^{-26}$ barns
number/cm^3	$= 4.4 \times 10^{38}$
energy density of ether	$= 68$ kg cal/cm^3
volume	$= 5.2 \times 10^{-63}$ cm^3/unit photon
density of ether	$= 3.16 \times 10^{-9}$ gram/cm^3

From the above it follows that both energy and action are atomicized entities and consist of very small and indivisible units or quanta, h/sec and h respectively.

6. Cavity Radiation and Steady States

As it was already mentioned, this theory is based on the principle of standing waves. Such standing fields may be found in Kirchhoff's "heated enclosures" and also in atoms.

The modern quantum physics is based mainly upon the properties of nuclear and electronic shells in atoms. A "steady state" is obtained when the periods of vibration are quantized according to certain quantum numbers. In this way the vibrations and spins are endlessly repeated and the dissipation of energy from the atom is thereby prevented.

From these considerations came the following supposition:

The entire universe is in fact a standing wave field.

In heated enclosures, the cavity is filled with a standing field of radiation only, the air having been previously exhausted. Of greatest interest is to note that as soon as a state of equilibrium is reached between the walls of the vessel and the radiation, no further addition of heat or any other energy is required to maintain the field. Thus, space has a certain capacity for absorbing and holding energy and that capacity increases with the temperature. The wave length is the measure both of the temperature and the specific energy content in a cavity.

In ether, the field acquires its maximum possible rate of vibration, $N = 2.3 \times 10^{23}$ per sec and therefore, the maximum specific action per cm^3. However, this action is not associated either with temperature or pressure.

One might ask here: how and why? The explanation is that in pure ether there are no collisions. Each unit photon vibrates in its own space quantum and does not collide with the next photon in the next space quantum. Heat and pressure will be generated only in the presence of matter which may be considered as a derivative and an impurity somehow created from ether itself in the distant past.

A steady state of a field, or radiation, is characterized by the fact that energy is neither absorbed nor emitted unless there be a perturbation of some

kind. In such a case a field may act as a reflector, a resonator or a transformer with respect to the said extraneous impulses.

All standing fields require a boundary. Ether itself must have a boundary which will reflect the waves coming in one direction and turn them around to travel in the opposite direction.

We can only speculate on what the boundary of ether might be.

It is conceivable that the absolute vacuum which surrounds the universe acts as an insulator or reflector through which the unit photons cannot pass, or if they do pass, can only pass with a finite velocity.

In such a case, the dissipation of ether may not be noticeable within historic times, providing however, that the universe is much larger than we think it is. The present estimate of the radius of universe is approximately 1.2×10^9 light years, but if the universe expands with the speed of light as it seems reasonable to assume, that radius is altogether too small by a factor of about 10.

Einstein had this same difficulty with his space time continuum because that continuum must also have a boundary.

It will be remembered that Planck discovered the quantum of action h in studying the heated enclosure in 1900. This phenomenal discovery forms the basis of modern physics and of this theory as well. Of particular interest is the de Broglie's discovery of waves which accompany any moving particle. The theory is based on Planck's quantum of action and Einstein's discovery of the mass-energy equivalence.

In this theory, de Broglie's principle is extended by reversal. Thus, when a body moves, it is surrounded by a swarm of unit photons, the waves. In reversal, whenever a body is surrounded by a swarm of unit photons, it must move. This leads to the most significant assumption, namely: all forces, momenta, kinetic energies, relativistic increments of masses, etc., are caused by means of transference of unit photons from one body to another. This transference may also be tied in with the law of entropy, meaning that free photons may be

transferred from a locus of a greater action to the locus of a lower action, but not in the opposite direction. By this means the principle of nuclear energy transference also becomes clearer. This factor also justifies us in assuming that ether is an inviolable standing field and possesses a higher frequency and action than any other entity in the universe, including the intranuclear binding energies.

7. The Subgravitational Masses

The idea that there exists matter which is not subject to either gravitation or inertia will be considered by most people as absurd and impossible.

Yet, by far the largest proportion of matter in the universe is of such a character. It was already calculated that ether consists of 4.4×10^{38} space quanta for each cm^3 and each such quantum contains a unit photon having a mass of 7.2×10^{-48} gram. From this, the specific gravity, or density, of ether is equal to 3.16×10^{-9} $gram/cm^3$. In other words, each km^3 of "empty" space contains three tons of matter, approximately.

The question now arises: just where does the line of demarkation, existing between imponderable and ponderable matter lie?

In ether or in light, there is only one unit photon in a space quantum. As is well known, these entities possess no ponderable mass and no inertia. Inertial effects will be noticeable in these entities only when they are perturbed by matter and thus lose their original structures. For example, light cannot exert pressure until it ceases to be light.

When a number of photons congregate in the same space quantum and the number increases up to a certain not now known amount, the entity will become ponderable, i.e., it will be affected by gravitation and will presumably exhibit inertial properties. But where?

We know already that an electron consists of 1.23×10^{20} unit photons. At this point the electric charges appear. This might be significant. It is conceivable, but not proved as yet, that electric charges, the gravitational effects and inertia all would appear together, at the same point of unit photon density.

This hypothesis ought to be investigated in laboratories. If it should prove to be true, the key to the long sought "unified theory" for which Einstein searched so long, would be found.

Another curious result would also be forthcoming. All ponderable mass increments should be integral multiples of the electron mass, 9.1×10^{-28} gram.

This might be possible to verify experimentally by measuring the relativistic mass increases, for example, in a cyclotron. If this hypothesis should be true, the relativistic mass increases will also be found to consist of finite and indivisible quanta, each such quantum being exactly equal to the "rest mass" of an electron.

8. The Mechanics of the Universe

The universe as a whole is an operative mechanism or process. Therefore, it must comprise all the operative elements which are sufficient and necessary for its operation. We know some of these elements, but the most important details are still missing. For example, we cannot explain the reasons for the universal "tremor" which pervades the world, the electric charges, the gravitation, inertia, the relativistic mass increase, the dual nature of light, the transference and equipartition of forces, momenta and kinetic energies, the real cause of inertia, the stability of the atoms and so on, ad libitum.

There is no question but that universe somewhat resembles a colossal thermodynamic machine. It operates on the basis of reversible and irreversible cycles and obeys that most fundamental of all laws of nature, the law of entropy.

Entropy means a degradation in the quality of energy and becomes evident wherever an irreversible thermodynamic cycle operates.

Entropy also means a transition from the state of orderliness into disorderliness.

It also means a change from less probable combinations into more probable combinations.

The reversible processes are those in which no energy is gained or lost. Such processes are quasi-perpetual because by means of "steady states" and "standing waves" the motions, vibrations and rotations are frictionless and continue forever without abatement. The best examples for this kind of operation are the ether, the atoms, the heated enclosures and the behavior of gases in general.

From a practical standpoint, the irreversible processes are much more interesting, because it is only by means of irreversible cycles that we are able to obtain energy from nature's reservoir, for our own uses.

It is an object of this article to show that the law of entropy governs not only the thermodynamic cycles but that it also applies to radiation.

In radiation, the temporal sequence of the emission of unit photons is the action.

The numerical magnitude of action is the definition of the quality of energy.

The law of entropy demands that in irreversible processes the magnitude of action must be degraded in each cycle.

All energies, including the nuclear energy, are based on the degradation of the action of unit photons, i.e., whenever the cycles are irreversible.

We may now ask the question: In precisely what manner is the action of unit photons transferred? Just as in heat transfer: the body having a higher temperature causes the heat to flow downwardly, toward lower temperatures but never, as a rule, in the opposite direction.

Similarly in radiation, energy having a higher rate of action will tend to dissipate itself into a number of lesser actions, but never in the opposite direction. The Compton effect, the radiation coming from the sun and stars, the nuclear energy as exemplified by fission, fusion and radioactivity, all follow the rules of entropy increase.

The law of entropy also throws an interesting light upon the history of universe. As was previously stated, entropy increase means also an increase in disorderliness. From this it follows that originally, universe must have been in a greater state of orderliness than it is now. Ether is the uppermost limit of orderliness, in fact, it is the orderliness itself. From this we conclude that ether is the origin of everything else, that is, the world as we know it in all its aspects and combinations, is only a derivative of ether.

9. Remarks on the Theory of Light

According to this theory, ether is a volume of very thin photon gas which vibrates in a steady state and at a constant wave length, throughout the universe.

The wave length is a constant of nature, 1.32×10^{-13} cm, the edge of the space quantum, while the time of one vibration is another constant of nature, the time quantum, 4.4×10^{-24} sec. Each space quantum contains one unit photon having a mass of 7.2×10^{-48} gram and a diameter of 2.7×10^{-25} cm.

Light spreads through ether in very much the same manner as does electric current through a wire. A unit photon arrives into a space quantum and dislocates the photon already there. That photon imparts the impulse to next quantum and photon, that one to the next and the next one with the result that the original impulse spreads all the way through the universe. When the said impulse finally collides e.g. with a mass particle, this will form a perturbation in the process, and the nature of light will correspondingly change. A beam of light is thus composed from a multitude of such elementary rays.

Action is the number of impulses per second, i.e., the sum per second of individual unit pulses each having an action numerically equal to $\underline{h}$ in each ray.

There is no way of finding out just exactly how the space quanta are arranged. Light finds its way through the quanta by following the principles of least action and least time, the said two principles being also known as the Maupertuis and Fermat principles, respectively.

Hence, the straight line propagation of light is not literally true. Light rays are transmitted in only approximately straight lines through ether. There might be some privileged directions along which the line of propagation is somewhat straighter than along others, but it is doubtful that this slight variation could ever be experimentally proved because the aberration at best is very minute.

This theory postulates, therefore, that light is a corpuscular, or more correctly, an action phenomenon caused by the dislocation of unit photons in ether.

It consists of individual unit pulses of the same velocity and magnitude h. The number of the pulses per second determines the action of each light ray and when the said action is multiplied by frequency, we obtain the familiar energy quantum. It is to be noted that the dimension of action is ergsec and that of energy is only erg.

As is well known, the light quanta occupy an enormous range when classified according to their wave lengths. Wave lengths are always expressible in integral numbers of space quanta and the reciprocals of frequencies are expressed in integral numbers of time quanta in this theory. The energy of any single ray is not affected by the distance traveled. From this it follows that the exact location of the source of ray is immaterial. It further follows that any ray passing through our instruments, as in Michelson-Morley experiment, for example, is an entirely local phenomenon. By this means it is possible to explain the "negative" result of said experiment without any recourse to the theory of relativity, as it will be furtherin shown.

10. On the Origin of Electric Charges

The nature and origin of the electric charges is easily the most baffling problem in the entire physics.

It is interesting to note that according to the present theory, the electric charges do not appear until the density of unit photons reaches 1.23×10^{20} per space quantum, i.e., the mass of the electron.

The theory further postulates that the above photon density is some kind of a critical number in nature, at which also the gravitation and the inertia make their first appearance. This should be checked and possibly verified by thoughtfully planned experiments. The proof would consist in checking the relativistic mass increments of electrons in a cyclotron. The increments should all be integral multiples of electron masses, i.e., quantized.

It seems that electric charge results from a spin. Furthermore, the spin must be three dimensional as for instance happens in a helix or a spherical helix, because, only in such a case would it be possible to distinguish between right-hand and left-hand directions. Ordinary circle or ellipse would not do because e.g., a clockwise rotating circle becomes anti-clockwise when turned upside down. But a right-handed helix always remains right-handed regardless of how it is being turned around.

By this means it would be possible to distinguish between positive and negative charges.

It remains to imagine some sort of process by means of which the charges of equal sign repel each other and those of the opposite sign attract each other. Induction and the pair formation from gamma rays are also terrific problems.

Ether is a positive field of equal potential throughout the space. Attraction and repulsion require fields of a variable potential. In particular, attraction is the result of a negative field while repulsion implies a positive field.

Fields may be superposed and added like vectors.

Hence, all fields are combinations of at least two fields, one of them being ether.

Gravitation is relatively easily explained because the field being attractive, is negative and has the characteristics of a shadow, i.e., the potential diminishes towards the body.

In electric charges, the situation is confusing because the positive and negative charges seem to be fully equivalent and yet they are different from each other.

Dirac's idea on positron is interesting but it is hardly understandable or imaginable. The idea of a negative energy levels and holes in what might be termed a plasma is attractive enough, but it is difficult to see the mechanism inside the atom which can produce such holes.

11. On Nuclear Energy

This theory throws an interesting light upon the possible geometrical structure of nuclei. In fact, the diameters of various nuclei may now be determined by calculation and more accurately than ever before.

This is due to the pecularity of the disposition of matter with respect to the space quanta.

As was previously stated, by the virtue of the rule of complementarity existing between space and matter, no particle can occupy more than one space quantum at the same instant. Similarly, no two nucleons can touch one another, and the minimum distance between the two adjacent nucleons must be equal to at least one space quantum, or to an integral multiple thereof.

Yukawa, in calculating the exchange forces, predicted the existence of mesons. He assumed that the center distance between two adjacent nucleons was 2.6×10^{-13} cm. This is in close agreement with this theory, in which the exact Yukawa distance should be 2.64×10^{-13} cm.

Another example may be mentioned in this connection. The radius of an alpha particle was estimated in laboratory measurements to be equal to 2×10^{-13} cm. The correct diameter is 3 space quanta and the radius is 1-1/2 space quanta, that is, 1.95×10^{-13} cm. Note the close agreement between laboratory measurements and the theory.

The reason why two nucleons cannot touch each other is that on account of the fields, the spins and the interposed de Broglie waves, such a contact is physically impossible. Furthermore, that fact has also been experimentally proved, witness the above two examples.

Nuclei contain "bottled-up" energy in the form of binding energies. As is well known, the nuclei consist of a plurality of major particles, protons and neutrons and of intranuclear spaces filled with matter or radiation of lesser density than the said nucleons.

As no nucleon can occupy more than one space quantum at any one time and no two nucleons can touch each other except through fields, as already stated, it follows that each nucleon must be surrounded by from six to twelve empty space cubicles, depending on the geometrical and crystalline arrangement of the said quanta. From this it follows that the nucleus is to a large extent empty. This writer once calculated the matter content of a uranium nucleus and found that the nucleus was approximately 92 per cent empty, based on a hexagonal crystalline structure presumed in the nucleus.

Matter obviously exists in two modifications, as it might be termed, the "hard" matter and the "soft" matter.

"Hard" matter is found in the solid cores of neutrons and protons. The "soft" matter consists of mesons, electrons, positrons and neutrinos.

As first suggested by Mosharaffa, it may be imagined that matter originated from "congealed radiation". Thus "hard" matter may be conceived to have first appeared in the form of droplets resulting from the condensation of ether.

Before such a condensation could take place, it was necessary for ether to be first organized into a complex consisting of definite and stable space and time quanta.

The said "droplets" became the cores of the neutrons and protons, the "hard" matter. The remaining "soft" matter was formed, according to this hypothesis, from the grouping of free unit photons about the said cores as a result of the spin and the perturbation of the structure of ether. By this means neutrons, protons and possibly antiprotons might have been formed.

Hence, we may explain why the said droplets or cores seem to be all exactly alike throughout the universe. The space quanta are simply a measure or the capacity of ether to form droplets of solid matter of a predermined diameter and density.

It is, therefore, reasonable to assume that the cores consist of matter 100% pure and inert. This explains why e.g., in fission or fusion only the "soft" parts of matter can be utilized for the production of energy while the cores remain unalterable and intact.

This form of reasoning leads to another interesting hypothesis about the cause of the stability of atoms. In this writer's opinion, the cause will be found in the principle of entropy. This hypothesis will be now discussed.

12. A Hypothesis on the Stability of Atoms

As it was already stated, all electromagnetic radiation is in substance of the same character. Each ray consists of a series of impulses and each impulse consists of a dislocation of a single unit photon. The only difference is in time intervals, as measured in time quanta, which separates one impulse from the next one.

Hence, the difference is in the action of the individual rays. Rays transmitted through ether follow the principles of least action and least time. Therefore, the successive pulses follow the same paths through ether. The paths of rays are very nearly straight lines but not necessarily exactly so.

Ether comprises one unit photon in each and every space quantum in a three-dimensional array. All these photons vibrate in their respective space quanta because of the steady state and a standing wave properties of ether.

From this it follows that ether represents the ultimate or maximum of action because the time interval between two successive pulses is the shortest possible and is exactly equal to one time quantum, 4.4×10^{-24} sec. All other electromagnetic rays exhibit greater time intervals, i.e., the successive pulses are separated from each other by a plurality of time quanta.

Action is closely analogous to temperature and temperature is a thermodynamical concept contained in the law of entropy. Namely, a transition from a state of lesser entropy, i.e., lesser time intervals between adjacent pulses to those of a greater entropy number is permissible, but the process is irreversible as previously stated.

Due to certain perturbations to which ether is subjected by the presence of matter, it is possible for a plurality of unit photons to occupy the same space quantum. In this way fields and matter may be created.

However, it is to be noted that each unit photon acts in its own behalf and has its own particular action. Therefore, while the energy content of a certain space quantum may be enormously increased by the infusion of a great number of unit photons, that does not mean that the action was increased to a point above that of

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However, it is to be noted that each unit photon acts in its own behalf and has its own particular action. Therefore, while the energy content of a certain space quantum may be enormously increased by the infusion of a great number of unit photons, that does not mean that the action was increased to a point above that of

ether. By definition, that is impossible, because ether already possesses the maximum of action and all other combinations or groupings of unit photons must, of necessity, possess a lesser action.

Thus, the intraatomic or intranuclear photon congregations possess more energy per space quantum, but less action than ether.

This brings into play the law of entropy. A transition of photons from ether into the atom is impossible after a certain level of saturation has been accomplished in atoms and a steady state has been obtained. We have here a situation in which two steady state configurations are imbedded one into the other. That is, atoms including nuclei, are fields of a lesser action imbedded into a field of a greater action. That such a thing is possible, can best be seen from the behavior of particles in cavity radiation. There, foreign particles, provided that they have smaller diameters than the wave length in the cavity, will vibrate together with the remainder of the radiation in the cavity indefinitely.

Hence, the origin of nuclear energy and the Aston mass defect may be explained. As Einstein already quoted said, "Matter is where the concentration of energy is great, and field is where the concentration is small". Nuclei, therefore, consist of matter and fields, all of which have a greater specific energy content and less action, than ether. Note that energy consists of unit photons and the quality of energy consists of the actions of the said photons. On the other hand, electric, inertial and gravitational effects are unobservable until a certain, predetermined density of unit photons per space quantum has been obtained.

It was already suggested that there might exist in nature a critical number, or a critical density of unit photons, 1.23×10^{20} per space quantum, at which point matter appears as such i.e., it becomes ponderable and capable of exerting electrical and inertial properties. We shall need another Millikan or a J. J. Thomson to prove this hypothesis experimentally. It was suggested in a preceding paragraph that relativistic mass increases might be quantized in accordance with the said critical number.

This would explain the true nature of the binding energies, i.e., the "soft" part of matter in nuclei. Thus in Aston curve, only such portions of unit photons which exceed the critical density would appear as parts of the nuclear mass. The rest, if any, would not be noticed or detectable by our instruments.

In producing nuclear energy, it appears that after the processes of fission or fusion have taken place, the nuclear bonds are broken to a certain extent and the captive unit photons are dispersed in the adjoining space, thus reducing both the action and density of the captive photons. The loss of action appears as a gain of energy, and the loss of density appears as a loss of ponderable matter. These two altered conditions seem to fulfill exactly Einstein's famous mass energy relation $E = mc^2$.

The available intranuclear action is dissipated in the form of Compton effects following the rule of increased entropy.

Thus, the only possibility of obtaining usable energy from any source is to generate irreversible processes in which the action and density of unit photons per quantum are reduced and entropy is correspondingly increased.

13. The Basis for a Unified Theory

It was a long sought object in science to find some sort of a mechanical or factual basis for a doctrine which would bring the electrodynamic, inertial or gravitational effects observable in nature, under the same unified heading.

Einstein was particularly diligent in search of such a principle.

Unfortunately, the mathematical and laboratory methods have proved insufficient to even approach this "problem of problems."

It was often said in the past that "God must have been a mathematician". Granting that this statement is true, it is by no means certain that God was using the same kind of mathematics which we are using.

The difficulty is in the fact that our mathematical and laboratory resources are full of holes. As this article proves to a certain extent, some of the most important factors in nature are totally inaccessible either to mathematical or laboratory treatment.

In the writer's opinion, the only possibility of coming anywhere near the solution of this intricate problem is by means of philosophy and invention.

Einstein himself was of this opinion when he said: "The bases of science which cannot be obtained by experience, can be attained only by free invention". In fact, in looking over the recent history of science, we come to the conclusion that most of the prominent physicists in the twentieth century were actually inventors in disguise. It is practically impossible to discover anything really new in physics or mathematics any more without first generating in one's mind an inventive or creative idea or, as Henry Poincare pointed out, "a number of closely related ideas, all aiming at the same objective". These ideas are usually of a subconscious origin.

In this theory it is believed a good beginning was made along these lines by first postulating that there must be an ether, i.e., a complex having a maximum of action and a minimum of unit photon content.

If we now assume a further hypothesis, namely, that in nature there is such a thing as a critical number, that is, a critical density of unit photons occupying the

same space quantum at which point the electrical charges, the inertia, and the ponderability of matter make their simultaneous appearance, the unifying principle will loom on the horizon, as already stated.

It was also previously suggested in this paper that the existence of the said critical number might be provable experimentally.

14. Remarks on the Theory of Relativity

An important byproduct of this theory is that it leads to a very considerable simplification of the theory of relativity.

As is well known, the said theory originated from the Lorentz-Fitzgerald equations and the Michelson-Morley experiments. Upon these bases, Einstein and Minkowski constructed an elaborate mathematical structure of a four-dimensional space-time continuum.

Strictly speaking, there is no direct connection whatever between space and time. Both are imaginary and mathematical concepts, something like two coordinates in geometry.

In this theory, the space and time quanta have been determined on the basis of certain constants peculiar to this universe of ours. It is easily imaginable that in some other universe, or, for that matter, in this universe when and if such constants of nature as the Planck constant, the atomic mass unit, the velocity of light and the density or specific gravity of the primordial mass were altered, the relations between space and time quanta would also be altered. Hence, there is no organic or immutable connection between space and time.

It is sufficient to recall the method according to which the space and time quanta were calculated in this theory:

$$\text{velocity of light} = \frac{\text{space quantum}}{\text{time quantum}} = c$$

$$\text{wave length of ether} = \frac{h}{mc} = d$$

in which the wave length is equal to the diameter of the largest solid particle which the nature can build and m is the mass of the said particle. The said diameter can also be determined by knowing the mass m and its density ρ, or by measuring the velocity of light.

However, it may be regarding the space-time continuum, the theory of relativity led to three basic discoveries in physics namely, a) the rule of the mass-energy equivalence, $E = mc^2$, b) to the mass increment of bodies at velocities approaching

that of light and c) in establishing the velocity of light as the maximum possible velocity which the nature can produce and its constancy in all directions.

As it happens, since Einstein's discoveries a great many things happened to science and now we find that all three theses of Einstein may be proved to be correct without even saying a word anywhere about relativity and its marvellous mathematics.

This goes to show that in the theory of relativity, the most important discoveries were made not by mathematics, but, we are tempted to say, in spite of it. They were discovered by invention and the mathematical dressing-up only served the purpose of making the inventions acceptable and palatable to certain mathematically inclined circles. This fact was well known e.g. to Soddy, already quoted. We now briefly analyze the three discoveries, a, b, and c.

a) Mass energy equivalence is amply proved by fission, fusion, pair formation, radioactivity and the Aston curve. No relativity needs to be mentioned here at all.

b) The mass increment (relativistic) follows from de Broglie's theory as modified by the present theory. It is impossible for a particle to reach a high velocity unless it was first accelerated by means of a force acting upon it. A force acts through unit photon transference which results in the kinetic energy, an "invisible cargo" of photons, which accompanies the moving particle. This theory further states that the said mass increments are quantized according to certain critical quantum numbers. Therefore, when a certain photon density in the accompanying de Broglie waves has been attained, the said waves will exhibit definite inertial and ponderable properties, i.e. they will become matter or a field.

c) Once the existence of space and time quanta is accepted, the limiting or maximum velocity which is possible in ether is automatically defined. The Michelson-Morley experiments need a further comment.

As was previously stated, in this theory the space and time quanta are absolute and unchangeable throughout the universe. This is the original Newton concept.

However, Michelson-Morley experiments have shown that there is no ether drift. This looks like a cont radiction, because there should be a drift when the earth is moving about 30 km/sec while ether remains stationary.

The contradiction can be explained in plain language and without a necessity of changing the time or space units, as was done in the theory of relativity.

We simply assume that earth has a field of its own which moves together with it through ether. This is the gravitational field which incidentally has a great resemblance to a shadow.

Hence, this moving field is something like an island universe moving through ether without a drag. However, the space and time quanta in this island universe are the same as in the stationary universe.

Light is an entirely local phenomenon and its velocity is determined by the ratio of space and time quanta providing however, that the rays are permitted to travel in straight lines, as in vacuum or thin air.

Hence, the Michelson experiment simply proves that light is moving in the earth's relative field instead of in an absolute field. Note than all other physical phenomena including the inertial effects, electric currents, chemical reactions, etc., behave in a similar manner. There is no reason to believe that light should behave differently from other forms of radiations or forces.

15. Kinetic Energy and the Relativistic Mass Increase

The nature of kinetic energy was a favorite topic among scientists since the time of Aristotle. It was believed that a flying arrow carried with it an "invisible cargo" which a similar arrow at rest did not possess.

According to this theory, the idea of an invisible cargo is substantially correct.

As was already pointed out, the forces and energies are transferred from one particle to another and from one body to another in the form of a swarm of unit photons. The transference takes place in collisions, accelerations or any other changes of momentum. De Broglie waves are such swarms and when the swarms or waves reach a certain critical density (probably 1.23×10^{20} photons per space quantum), the increase of mass and inertia become measurable. Otherwise, i.e., below the critical density, the de Broglie waves are only fields having no measurable inertia or ponderable mass.

Hence, in a relativistic mass increase the major particles which have been accelerated, remain in a state in which they were originally and their numbers do not change. It is only the mass of the de Broglie wave which changes.

16. On gravitation and inertia

The quantized and energized ether is the cause of gravitation and inertia.

Mach and Einstein assumed that both effects were caused by the metric space-time complex which was energized by masses allegedly evenly distributed in the universe.

This theory does not require any such explanation. The gravitational field is spread over the ether field as over a carpet. As it was previously stated, when the earth is moving in its orbit around the sun, the gravitational field moves together with it while ether remains stationary. Nevertheless, the Michelson-Morley experiments may be explained in a simple manner by merely assuming that light being a local phenomenon independent of its source follows the moving field and not the stationary one. In this manner, the velocity of light remains constant in all directions and behaves in exactly the same manner as if the earth were not moving at all.

Inasmuch as the gravitational field exerts an attraction upon matter, it follows that the field is negative, i.e., it consists of a weakening of the ether field in the vicinity of masses. From this we conclude that gravitation is substantially a shadow effect. Inertial effects are entirely local, i.e., they do not comprise a field as does the gravitation and therefore are not related to gravitation.

As was stated, the structures of matter and ether are complementary of each other and comprise two congruent spatial divisions or networks.

For this reason there is no inertial effect observable during an absolute motion, i.e., a uniform motion in a straight line.

However, when forces act upon a body, the disposition of the accompanying de Broglie waves changes: they may increase in content and also may become non-symmetrical with respect to the moving body. This results in a change of momentum or direction and this change in turn reacts upon the structure of ether.

It may be assumed that ether resists a change of momentum and therefore forms a basis for a reaction to forces. It is readily seen that Newton's law of action and reaction is true not only among material bodies but it also includes ether.

Because, in following a chain of actions and reactions however long, ultimately we always must end in contact with space or ether.

Hence, inertia could not exist if ether did not exist at the same time, because all inertial changes and effects involve a transference of unit photons. On the other hand, it is impossible for unit photons to be transferred from one place to another without the use of space and time quanta, i.e., ether.

17. Causality and Determinism

This theory deals not only with problems in physics but also with philosophy.

Once we accept the idea that the entire universe, including ether, is in a state of quasi-perpetual tremor in which all particles and unit photons residing in space quanta are forever moving, vibrating or rotating, we must conclude that universe as a whole, resembles a living organism.

Of particular significance is to note that universe has gone through a long period of evolution before it has reached its present complex state. This is due to the law of entropy.

Accordingly, universe has evolved from a state of pristine orderliness, which is pure ether into a state of maximum or increased probabilities, which is chaos or varieties.

As was stated, ether is an entity which comprises a maximum of action and a minimum of unit photon content per space quantum. Entropy causes the said action to diminish and the specific photon content to increase. In this manner, matter was formed from ether.

In this article we have postulated that space and time are discontinuous and consist of indivisible units or quanta. This completes the picture of quantization, which condition of matter and events embraces the entire universe and makes it appear as consisting entirely of integers, spatial, temporal and energetic, containing no fractions.

This is important. Any entity containing no fractions cannot be divided into parts with a mathematical accuracy. After each division there is usually a remnant. From this it follows that the effect is never or very seldom exactly equal to the cause and usually equals it only approximately.

So, after each event, there is left a remnant of uncertainty. Through the course of time, these remnants are integrated and may become sizable and important. In other words, the future is not predictable with an absolute certainty from the past or present, nor is the past exactly determinable from the present.

It may be added that life itself would be impossible without the said uncertainties. Evolution is based therefore, on the existence of mutations and uncertainties and those again are based upon the quantized structure of nature.

18. On Fields

Fields are the connecting link between matter and ether. Ether cannot act against matter except through fields and matter cannot react upon ether except through fields.

From this it follows that fields cannot be formed in the absence of matter and ether. In fields, the action of ether is diminished and the specific photon content is increased.

In matter, the procedure is extended in that action is further diminished and the specific photon content is further increased.

This metamorphosis is due to the law of entropy.

Fields are of two kinds, the "closed" and "open" fields. Closed fields are self-sufficient and persist on the basis of standing waves as quasi-perpetual mechanisms.

For example, atoms are such mechanisms. Other fields are open such as the electromagnetic radiation and require a continuous energy or photon influx for their maintenance.

Gravitation is a unique field in that it is open and yet it requires no energy influx for its existence. From this we conclude that gravitation is a shadow field, caused by shadow of matter complexes falling upon ether. In this manner it causes a perturbance in the action of ether generally known as gravitation.

All fields are spread over ether and are, therefore, quantized both in spacing and the periods of vibration. Hence, we conclude that gravitation, being a shadow field, must have the same wave length as ether, 1.32×10^{-13} cm.

19. On Thermonuclear Energy

Atoms are geometrical configurations formed from ether. Some of these configurations are more probable than others.

As a rule, it might be said that due to the law of entropy, the tendency in nature is to form more probable combinations from the less probable ones.

The principles of Maupertuis and Fermat state that the courses of events always select the most probable paths, the paths of least action and least time

Correspondingly, the tendency is to form units containing the strongest possible bonds and the least amounts of energy. In this process of evolution, energy and action are liberated. This is the source of energies issuing from the processes of fission, fusion and radioactivity.

In fusion, that is, in the thermonuclear process, the object is to break up the less probable combinations and thus obtain energy by forming more probable combinations.

It is impossible to break up a "steady state" nucleus, having a certain degree of action except by means having a superior action. In other words, it is necessary to transform the structures of atoms to be worked on into a plasma, i.e., disassociated matter.

Strictly speaking, the term "thermonuclear" is a misnomer, because in dealing with photonic transmutations temperatures as such do not exist. Here we are dealing with actions only which are not to be associated with the macroscopic concept of temperature.

Temperature is an entirely extraneous and electronic or molecular phenomenon and has nothing to do with nuclei and nuclear fields.

Unfortunately, or fortunately, we are unable to use the vast amounts of energy residing in ether (about 68 kg calories per cm^3) because ether is a closed and untouchable field.

However, there might be some other electromagnetic radiations, such as certain gamma rays which possess sufficient action to penetrate the bonds of promising atoms and might be used to recombine them into structures possessing less energy.

The practical value of this theory resides mainly in the fact that it stresses the importance of action in lieu of temperature as heretofore, in the scheme of obtaining thermonuclear energy. Hence, an apparatus combining the fission and fusion processes in a single unit is indicated by this theory. An H bomb is an apparatus of this kind.

20. The specifications of ether

NAME	SYMBOL	VALUE	REMARKS
Velocity of light	c	3×10^{10} cm/sec	
Quantum of action	h	6.6×10^{-27} erg sec	Planck
Mass unit	m	1.66×10^{-24} gram	The solid core of a nucleon.
Frequency of ether	N	2.3×10^{23}/sec	Also the number of unit photons in m
Space quantum	d	1.32×10^{-13} cm	Also the diameter of core
Volume of m	Vol_m	1.2×10^{-39} cm^3	
Specific gravity	γ	1.38×10^{15} b/cm^3	Of the core and photons
Mass of unit photon	μ	7.2×10^{-48} gram	$= \frac{m}{n}$
Energy of m	E_m	1.5×10^{-3} erg	$E_m = mc^2$
Energy of μ	E_μ	6.48×10^{-27} erg	$E_\mu = c^2\mu$
Energy of m		3.57×10^{-14} kg cal	934 MEV
No. of quanta/cm^3		4.4×10^{38}/cm^3	Number of space cubicles/cm^3
Energy of μ		1.55×10^{-37} kg cal	
Energy of ether/cm^3		68 kg cal	
Volume of		5.2×10^{-63} cm^3	
Diameter of μ		2.7×10^{-27} cm	
Specific gravity of ether		3.16×10^{-9} g/cm^3	
Time quantum		4.4×10^{-24} sec	
Volume of matter in ether		2.3×10^{-24} cm^3/cm^3	Emptiness of ether
Mass of electron	m_e	9.1×10^{-28} gram	
Number of photons in electron		1.23×10^{20}	
Cross Section of μ		5.7×10^{-50} cm^2	5.7×10^{-26} barns

A NEW THEORY ON ETHER AND MASS-ENERGY RELATIONS
By Nikola J. Trbojevich (Nicholas J. Terbo) (1886-1973), September 24, 1959

To: Dr. James Corum and Dr. Jasmina Vujic: 30 October 2000

From: William H. Terbo

Enclosed is a copy of my father's space-time physics theory that he developed over forty years ago. I had set it aside several months ago to send to Jim, he being one of the few people I know who has both the knowledge of the field and the (hoped for) willingness to review and comment on what is to me is a fairly esoteric subject. When I mentioned the work to Jasmina during my October 14-17 visit to UC Berkeley to speak to her Tesla history course, she asked for a copy for review. It was the spark I needed to get this effort moving.

I've reread the work today. The words are easy, but the concepts aren't so easy for me so far removed from my physics education. (It put me in mind of reading Stephen Hawking's "A Brief History Of Time." It took me almost two transcontinental air trips to momentarily absorb his less than 200 pages of similar material.) A lot of credit must go to my college friend and tournament bridge partner, the late Burt Randolph, who spent many weeks with my father acting as a "devil's advocate" to force dad to defend his theory, and then managing the organization of the work into its present readable form. (Burt got his doctorate in Mechanical Engineering at Purdue while I was getting my bachelor's.)

This theory is a pretty substantial departure for my father. Most of his previous work was in the invention of various gears, most notably the basic patent on the Hypoid gear in 1923. It was the first gear design using the application of advanced mathematics. (Tesla called my dad "my nephew, the mathematician.") This theory was pretty aggressive considering the year, 1959, and my father's age, 73. Research was complicated as the publishing of much new nuclear science technology was restricted for security reasons, so more credit is due for dad's creativity. I know he spent at least seven or eight years developing his knowledge in the field.

I would appreciate a couple of very brief comments done at your leisure. I really have only two questions that need resolution for my satisfaction. First, was my dad really on to something important, or was it too much of a leap? Second, is the theory good but outdated, or overtaken by current science?

You may distribute this material to your academic colleagues if you wish.

Thanks,

Bill WHT/njtkl

FOREWORD

This paper deals with the structure of the universe, the nature of space and time and the mass-energy relations.

The subject matter is of the kind which is not readily approachable either by laboratory experiments or mathematics. It is the product of free invention.

Nevertheless, the paper contains several ideas relating to nuclear and thermo-nuclear energies, the theories of quanta and relativity, which may have important practical consequences.

The writer spent a lifetime as a free-lance engineer and inventor. It is another object of this paper to demonstrate that the art of invention, when pursued purposively, diligently and professionally, may easily become a most valuable tool in scientific research.

I wish to express my particular thanks to Dr. B. W. Randolph who has read the first two drafts of this paper and has offered a number of valuable suggestions in this connection.

NIKOLA J. TRBOJEVICH

September 24, 1959

Santa Monica, Calif.

UNITED STATES PATENT #3,349,002 "NUCLEAR REACTOR"
By Nikola J. Trbojevich – Issued October 24, 1967 (Filed March 28, 1958)

To: Dr. James Corum and Dr. Jasmina Vujic 30 October 2000

From: William H. Terbo

Attached is a copy of my father's final U.S. Patent, FYI.

Father had a total of between 150 and 200 patents, U.S. and foreign. He was an independent inventor and consultant almost all of his life with a specialty in gears of all forms. His most famous invention was the mathematically conceived Hypoid gear in 1923. Used in the rear axle differential in rear drive automobiles, the gear allows the drive shaft from the engine to intersect the rear axle several inches below the axle centerline. Together with his invention of the even more complicated gear shaping (cutting) machinery (still in use today) to manufacture Hypoid gears, it changed the profile of all automobiles by 1931 (tall and boxy until 1930, six to eight inches lower after that). Among some of his other inventions were: all types of vehicle steering systems, constant velocity universal joints, positive displacement pumps, gauges and finally, the nuclear reactor. He worked for corporations during the Second World War and ended his career as a college professor.

The most interesting aspect of the Reactor patent is the extraordinary time between filing and issuance. Considering that the reactor invention was germinating for at least a year or two before filing, such a patent was far ahead of its time. This was not lost on the Patent Office. Dad assumed that they couldn't believe that an independent inventor, outside the government driven system, could devise something that was the preserve of academics and engineers working in a "secret" environment. The patent search was likely complicated by security concerns, as many nuclear patent applications were held up, or sequestered, to prevent disclosure to unfriendly or competitive foreign parties.

Dad believed he was on the FBI "watch" because of his work on nuclear technology (and because of his very close family relationship to various people in the highest levels of the post war Yugoslav government). He applied for a new passport just to see if he could get one. He got it, but it didn't change his mind about the "watch."

Regards,

Bill WHT/njtkm2

Oct. 24, 1967 N. J. TRBOJEVICH 3,349,002

NUCLEAR REACTOR

Filed March 28, 1958

FIG.1.

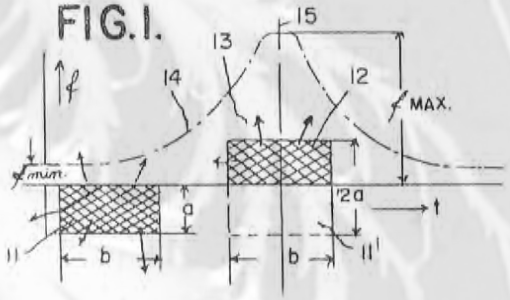


FIG.2.

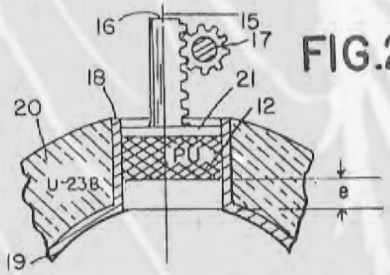


FIG.3.

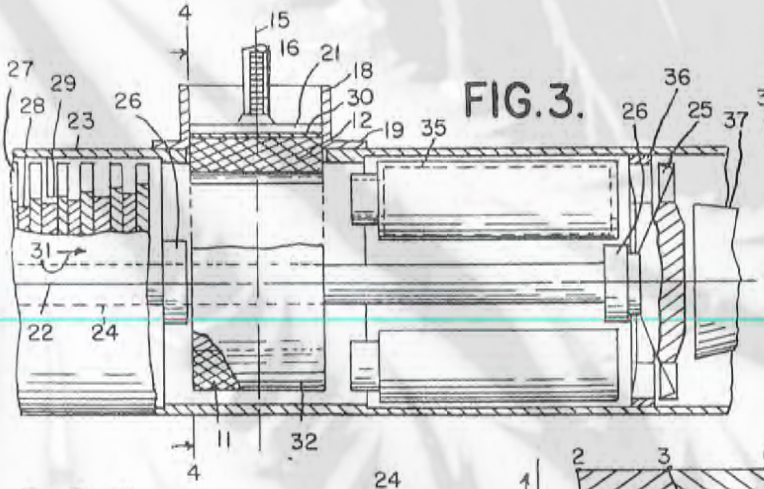


FIG.4.

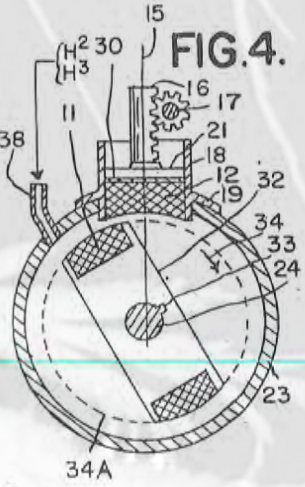


FIG.5.

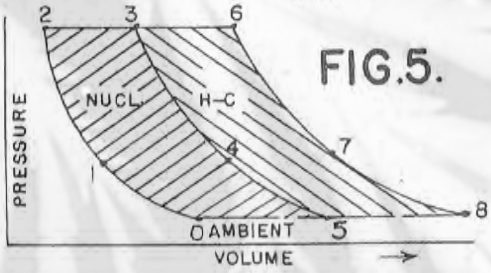


FIG.7.

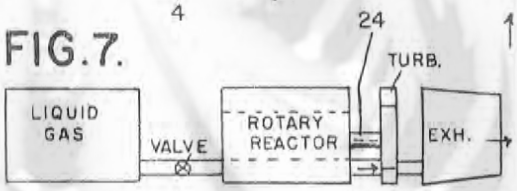
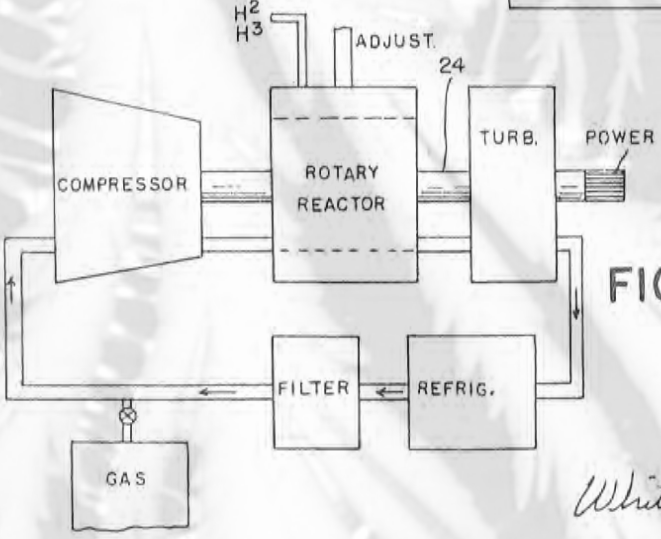


FIG.6.



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BY
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ATTORNEYS

United States Patent Office

3,349,002
Patented Oct. 24, 1967

3,349,002
NUCLEAR REACTOR

Nikola J. Trbojevich, 8106 E. Jefferson Ave., Detroit, Mich. 48214

Filed Mar. 28, 1958, Ser. No. 724,713
4 Claims. (Cl. 176—21)

The invention relates to an improvement in nuclear reactors which may be used in the propulsion of aircraft, rockets and vehicles, for breeding and the like.

The novelty resides in the construction of a rotary and fast reactor in which the energy is produced in a series of discontinuous pulses, instead of continuously as in prior designs. In order to accomplish this, the new reactor comprises a rotor and a stator in which the fuel elements are distributed in a plurality of discrete lumps or pads along the adjoining circumferences of the said rotor and stator.

The arrangement is such that whenever, as a result of rotation, two such lumps arrive in a juxtaposite position, a momentary chain process is established resulting in what might be called an intense nuclear spark. The said spark is promptly extinguished afterwards and the said fuel lumps are cooled and scavenged by means of a copious supply of compressed air or gas.

The object is to produce a momentary neutron and power pulse of the greatest possible intensity and that, without a damage to the fuel elements and the adjoining mechanism.

Another object is to construct a nuclear turbojet upon this principle.

Another object is to construct a combination in which a turbojet may be actuated either by a nuclear or a conventional fuel, together or separately.

Another object is to construct a turbojet or rocket which does not require oxygen or ordinary fuel for its operation.

A further object is to devise a compact mechanism comprising a compressor, a reactor and a turbine in which all three elements are mounted in the same tube and are rotatable by means of a single shaft.

Another object is to provide for the regulation or discontinuation of the nuclear fission by means of the withdrawal of the elements in the stator.

In the broad sense, the object is to construct a rotary reactor in which the momentary output is a function of the angular displacement of the rotor with respect to the stator and the duration of each pulse is dependent upon the angular velocity of the rotor. By this means the output is controlled in a relatively simple manner.

In the drawings:

FIGURE 1 is a geometrical diagram explanatory of the theory of the new reactor.

FIGURE 2 is a portion of the stator showing the means for adjustment and the disposition of the fertile material needed for breeding.

FIGURE 3 is a longitudinal cross section of the new nuclear turbojet operable by a combination of nuclear and conventional fuels.

FIGURE 4 is the section taken in the plane 4—4 of FIGURE 3.

FIGURE 5 is an indicator diagram of the Brayton cycles used in the turbojet.

FIGURE 6 is a schematic representation of a closed cycle modification.

FIGURE 7 is another modification diagrammatically representing the cycle used for the propulsion of rockets and missiles.

The theory will be first explained.

In FIGURE 1 two highly enriched fissionable masses **11** and **12** are shown and indicated by cross-hatching.

The first said mass **11** is attached to a high-speed rotor and moves *tangentially* with respect to a similar mass **12** affixed to the stator.

In the coordinate diagram the abscissa is taken as the time t while the ordinate is the neutron flux f.

The said two masses, which are taken to be two similar parallelepipeds for simplicity are so selected that each parallelepiped is subcritical per se, but when they unite in a single parallelepiped **12** and **11'**, the latter position being indicated by the dotted lines in the axis **15** of the diagram, they become critical and generate a divergent chain process. The criticality is obtained by reducing the circumference of the combined cross section of the parallelepipeds from $4a+4b$ to $4a+2b$, as indicated in the diagram. The difference of $2b$ in the combined cross sections is selected to be just sufficient to raise the flux in the axis **15** to a predetermined value of f max. In the flux curve **14** the residual or minimum flux is indicated by the symbol f min.

It is to be noted that this process is somewhat similar to the well known process which is or was used for setting off atom bombs, except that the divergent chain process is now extinguished practically as soon as it is started, i.e., usually within 10^{-8} sec.

The arrows **13** indicate the escaping neutrons from the cross section ab of the parallelepipeds.

In FIGURE 2 a portion of the stator is diagrammatically shown. The fissionable mass **12**, also marked with PU (meaning plutonium) is longitudinally translated along the axis **15** by means of a rack **16**, plate **21** and pinion **17**. The object is to increase the width of the gap e for the purpose of discontinuing the chain process when so required. The said mass **12** is guided in a thin walled holding member **18** which also supports a considerable mass **20** of fertile material marked U–238 (uranium) at its outer circumference for the purpose of breeding. In airplanes and rockets I usually omit the said fertile material in order to reduce the weight of the apparatus and relegate the operation of breeding the required concentrated nuclear fuel to suitable ground installations.

In FIGURES 3 and 4 a complete nuclear turbojet apparatus is partly diagrammatically shown. The novelty resides in the design of the reactor and the method of operation wherefore the remaining elements, being well known, will only be briefly described.

As is seen in FIGURE 3, the apparatus is built along two mutually perpendicular and intersecting axes, viz, the horizontal axis **22** which is also the axis of the outer tube **23**, the drive shaft **24**, two bearings **26** and the turbine wheel **25**, the latter being integrally formed with the said shaft **24** and the perpendicular axis **15** which serves as the main axis of the reactor and as such is coaxial with the elevating rack **16**, the plate **21**, the bond **30**, the fuel pad **12**, the hollow rectangular insert and holder **18** and its integrally formed extensions **19**. The said holder **18** is affixed to the outer tube **23** in a suitable rectangular aperture formed in the wall of the latter by riveting or welding the said two elements together.

The ambient air enters the device at the left end of

FIGURE 3, as shown by the arrow **31**, and is first slowed down, then compressed, then heated, expanded in the turbine and finally, accelerated through the exhaust, i.e., the operation exactly corresponds to the well known Brayton cycle (see also FIGURE 4), which is used in ordinary turbojets.

The compressor comprises a rotor keyed to the shaft **24**, the said rotor consisting of a plurality of bladed disks **27** and intervening spacers **28**. The stator is affixed to the outer tube **23** and comprises a plurality of bladed rings, each having a plurality of blades **29** adapted to occupy the spacings provided by the said spacer disks **28**. Only one blade **29** is shown in the drawing, for clarity. It is further to be noted that the stator rings are split each in two halves in order that they may be assembled over the rotor.

The design of the new reactor having a vertical axis **15** will be readily understood from FIGURE 4. The rotor **32** is mounted upon the shaft **24**, is secured in position by means of the key **33** and rotates in the direction of the arrow **34** in unison with the rotor of the compressor **27** and turbine **25**. The said rotor usually has the form of a flat and exactly balanced slab capable of housing two similar fissionable masses **11** at its two ends where it is bounded by the cylinder **34A**. The adjustment of the outer fissionable mass **12** by means of a rack **16** and pinion **17** was already explained in connection with FIGURE 2 while the flux curve **14** generated by the reactor was similarly shown in connection with FIGURE 1.

Adjacent to the reactor are two oil burner tubes **35**. These may be of an entirely conventional design and need not be explained here in detail. However their purpose and role in the makeup of this invention is significant. I conceived the idea of a light and powerful source of nuclear energy for the propulsion of aircraft which could be constructed providing that the fission products could be blown out into the ambient air in their nascent state, as already mentioned in the preamble. Hence, the exhaust gases are radioactive and ionized. Therefore, the reactor cannot be very well operated until the plane has ascended to a safe distance away from the airfield. For this reason, this turbojet is designed to operate both on conventional and nuclear fuels.

The turbine **25** is preceded by a stationary diffuser **36**. The end cone **37** is used for the purpose or gradually increasing the effective cross section of the tailpipe and thus provides an orderly expansion of the gases issuing from the said turbine.

The tube **38** in FIGURE 4 serves for the injection into the reactor of neutron-rich light isotopes such as deuterium (H^2) or tritium (H^3) for the purpose of boosting the power by increasing the number of fissions. In this method it is possible to do so because of the much higher peaks of the flux curve **14**, FIGURE 1, obtainable in this reactor than could be obtained in the conventional or steady-flow reactors.

In FIGURE 5 an indicator diagram characteristic of the operation of the jet engine above described is shown. The diagram is of the Brayton type as already stated and corresponds to the dual drive shown in FIGURE 3, i.e., the incoming air can be heated either by nuclei or by hydrocarbons or by both. Thus, in the *pv* diagram, the first cycle relating to the nuclear modification and marked NUCL starts from the point **0** having first an adiabatic compression **0–1**, the ram effect, and **1–2**, the rise in the compressor. The horizontal line **2–3** indicates heat induction into the reactor, the said heat quantity adding to the volume and velocity of the gases but not to their pressure. From the points **3** to **4**, the turbine adiabatically expands the gases just sufficiently to produce enough torque to operate the compressor and the reactor and no more. From the points **4** to **5**, the gas expands through the exhaust tube down to the ambient and thus provides the jet needed for the propulsion of the craft.

The hydrocarbon cycle marked H–C runs through the points **5 3 6 7 8** and is quite similar to the one just described. The area of the combination of the two diagrams **0 2 6 8** represents the maximum power which the apparatus is capable of furnishing.

In FIGURE 6 a schematic diagram shows, as a modification, the application of the new reactor in a closed cycle. The advantage of the closed cycle resides in the fact that there is no radioactive gas issuing from the turbine into the exhaust. For this reason, the modification is suitable for the purposes of breeding, for power production, for submarines, etc. The elements in the cycle, FIGURE 6, are all so clearly marked that they will be clearly understood and no further explanation will be necessary.

In FIGURE 7, a very simple arrangement is shown according to which rockets and missiles may be propelled by means of nuclear power through empty space.

It should be noted in this connection that rockets are driven on the principle of equipartition of momenta and inasmuch as the momentum is the product of mass and velocity, it follows that energy alone is insufficient to propel a rocket in an empty space. In FIGURE 7 the matter to be backwardly ejected from the rocket is carried in the tank marked "Liquid Gas." A too rapid expansion of this gas is prevented by means of a rotating turbine wheel which also furnished the required power to the rotor of the reactor while the latter furnishes the heat energy required for the acceleration of the gas and the power lost in the turbine.

What I claim as my invention is:

1. A reactor comprising a cylindrical core rotatable about an axis, an outer stationary member tangential of the said core and two fissionable and subcritical masses respectively affixed to the said core and member and so selected that when the first said mass tangentially bypasses the second said mass in its proximity, the combined masses become momentarily hypercritical and momentarily generate a divergent fission chain reaction and in which the mass in the outer member comprises a slide and means for bodily moving the said mass in the said slide in a direction perpendicular to the said axis, for the purpose of adjustment.

2. A reactor comprising a cylindrical core rotatable about an axis, a hollow cylindrical member enveloping the said core, a plurality of fissionable masses discretely distributed along the adjoining circumferences of the said core and member, and means for moving the masses in the said enveloping member in a direction perpendicular to the said axis.

3. In a reactor, a combination of a rotor with a stator in which the said two members comprise a plurality of discrete fissionable units, in which the units in the said stator are outwardly retracted to provide a clearance, in which the stator is provided with means for injecting into the rotor additional neutron-rich material of the class consisting of deuterium and tritium and in which the speed of rotation of the said rotor is predetermined to produce a series of neutron pulses of the required magnitude and frequency.

4. A reactor according to claim 3 in which the units are over fifty percent enriched and require no moderator for their proper functioning.

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H. H. BRADLEY, S. F. STONE, R. C. LYNE, *Assistant Examiners.*

ON RADIANT MATTER.*

By WILLIAM CROOKES, F. R. S.

I.

TO throw light on the title of this lecture I must go back more than sixty years—to 1816. Faraday, then a mere student and ardent experimentalist, was twenty-four years old, and at this early period of his career he delivered a series of lectures on the general properties of matter, and one of them bore the remarkable title, "On Radiant Matter." The great philosopher's notes of this lecture are to be found in Dr. Bence Jones's "Life and Letters of Faraday," and I will here quote a passage in which he first employs the expression *radiant matter:*

> If we conceive a change as far beyond vaporization as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of radiant matter; and as in the last conversion many qualities were lost, so here also many more would disappear.

Faraday was evidently engrossed with this far-reaching speculation, for three years later—in 1819—we find him bringing fresh evidence and argument to strengthen his startling hypothesis. His notes are now more extended, and they show that in the intervening three years he had thought much and deeply on this higher form of matter. He first points out that matter may be classed into four states—solid, liquid, gaseous, and radiant—these modifications depending upon differences in their several essential properties. He admits that the existence of radiant matter is as yet unproved, and then proceeds, in a series of ingenious analogical arguments, to show the probability of its existence.†

* A lecture delivered before the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879.

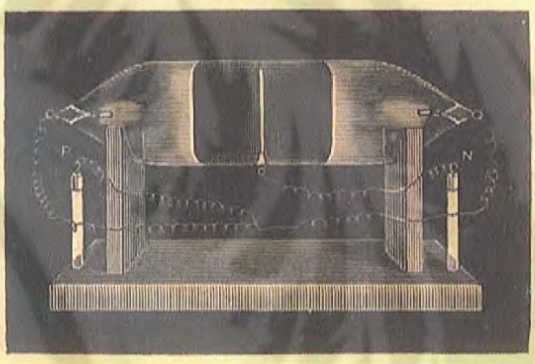
† I may now notice a curious progression in physical properties accompanying changes of form, and which is perhaps sufficient to induce, in the inventive and sanguine philoso-

able to which I am now about to call your attention. So distinct are these phenomena from anything which occurs in air or gas at the ordinary tension, that we are led to assume that we are here brought face to face with matter in a fourth state or condition, a condition as far removed from the state of gas as a gas is from a liquid.

Mean Free Path—Radiant Matter.—I have long believed that a well-known appearance observed in vacuum-tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the mean free path of the molecules lengthens and contracts. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size; and, if the vacuum is insufficient to permit much play of the molecules before they enter into collision, the passage of electricity shows that the "dark space" has shrunk to small dimensions. We naturally infer that the dark space is the mean free path of the molecules of the residual gas, an inference confirmed by experiment.

I will endeavor to render this "dark space" visible to all present. Here is a tube (Fig. 1), having a pole in the center in the form of a

FIG 1.



metal disk, and other poles at each end. The center pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the center. When the exhaustion is not very great, the dark space extends only a little on each side of the negative pole in the center. When the exhaustion is good, as in the tube before you, and I turn on the coil, the dark space is seen to extend for about an inch on each side of the pole.

Here, then, we see the induction-spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space is the measure of the mean free

Radiant Matter exerts Powerful Phosphorogenic Action where it strikes.—I have mentioned that the radiant matter within the dark space excites luminosity where its velocity is arrested by residual gas outside the dark space. But if no residual gas is left, the molecules will have their velocity arrested by the sides of the glass; and here we come to the first and one of the most noteworthy properties of radiant matter discharged from the negative pole—its power of exciting phosphorescence when it strikes against solid matter. The number of bodies which respond luminously to this molecular bombardment is very great, and the resulting colors are of every variety. Glass, for instance, is highly phosphorescent when exposed to a stream of radiant matter. Here (Fig. 2) are three bulbs composed of different glass: one is uranium glass (*a*), which phosphoresces of a dark-green color; another is English glass (*b*), which phosphoresces of a blue color; and the third (*c*) is soft German glass—of which most of the apparatus before you is made—which phosphoresces of a bright apple-green.

My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the radiant discharge; but many other substances possess this

FIG. 3.



phosphorescent power in a still higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When the sulphide is exposed to light—even candle-light—it phosphoresces for hours with a bluish-white color. It is, however, much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube.

intense red line, a little below the fixed line B in the spectrum, having a wave-length of about 6,895. There is a continuous spectrum beginning at about B, and a few fainter lines beyond it, but they are so faint in comparison with this red line that they may be neglected. This line is easily seen by examining with a small pocket spectroscope the light reflected from a good ruby.

There is one particular degree of exhaustion more favorable than any other for the development of the properties of radiant matter which are now under examination. Roughly speaking it may be put at the millionth of an atmosphere.* At this degree of exhaustion the phosphorescence is very strong, and after that it begins to diminish until the spark refuses to pass. †

I have here a tube, Fig. 5, which will serve to illustrate the dependence of the phosphorescence of the glass on the degree of exhaus-

* 1·0 millionth of an atmosphere = 0·00076 millim.
1315·789 millionths of an atmosphere = 1·0 millim.
1,000,000· " " " = 760·0 millims.
" " " " = 1 atmosphere.

† Nearly a hundred years ago, Mr. William Morgan communicated to the Royal Society a paper entitled "Electrical Experiments made to ascertain the Non-conducting Power of a Perfect Vacuum," etc. The following extracts from this paper, which was published in the "Philosophical Transactions" for 1785 (vol. lxxv., p. 272), will be read with interest :

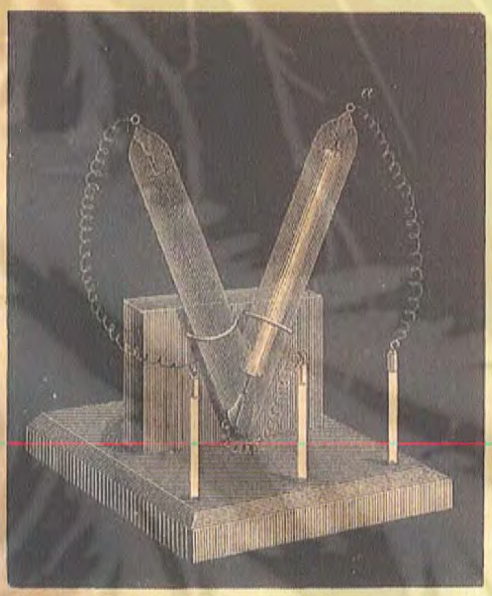
A mercurial gage about fifteen inches long, carefully and accurately boiled till every particle of air was expelled from the inside, was coated with tin-foil five inches down from its sealed end, and being inverted into mercury through a perforation in the brass cap which covered the mouth of the cistern, the whole was cemented together, and the air was exhausted from the inside of the cistern, through a valve in the brass cap, which, producing a perfect vacuum in the gage, formed an instrument peculiarly well adapted for experiments of this kind. Things being thus adjusted (a small wire having been previously fixed on the inside of the cistern to form a communication between the brass cap and the mercury, into which the gage was inverted), the coated end was applied to the conductor of an electrical machine, and, notwithstanding every effort, neither the smallest ray of light, nor the slightest charge, could ever be procured in this exhausted gage.

If the mercury in the gage be imperfectly boiled, the experiment will not succeed; but the color of the electric light, which in air rarefied by an exhauster is always violet or purple, appears in this case of a beautiful green, and, what is very curious, the degree of the air's rarefaction may be nearly determined by this means; for I have known instances, during the course of these experiments, where a small particle of air having found its way into the tube, the electric light became visible, and as usual of a green color; but the charge being often repeated, the gage has at length cracked at its sealed end, and in consequence the external air, by being admitted into the inside, has gradually produced a change in the electric light from green to blue, from blue to indigo, and so on to violet and purple, till the medium has at length become so dense as no longer to be a conductor of electricity. I think there can be little doubt, from the above experiments, of the non-conducting power of a perfect vacuum.

This seems to prove that there is a limit even in the rarefaction of air, which sets bounds to its conducting power; or, in other words, that the particles of air may be so far separated from each other as no longer to be able to transmit the electric fluid; that if they are brought within a certain distance of each other, their conducting power begins, and continually increases till their approach also arrives at its limit.

gas follows all the convolutions into which skillful glass-blowers can manage to twist the glass. The negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at the ordinary exhaus-

FIG. 6.

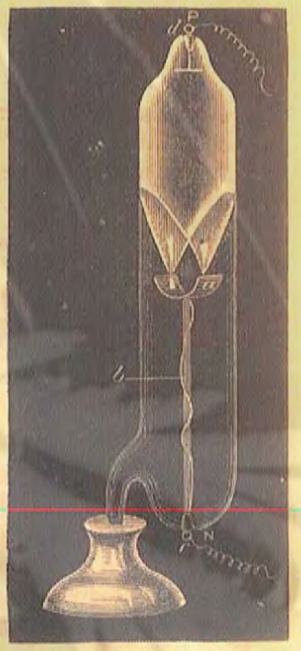


tion hitherto used to get the best phenomena of vacuum-tubes. But at a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction-spark passes through them—an appearance of cloudy luminosity and of stratifications—disappear entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments, the only light observed is that from the phosphorescent surface of the glass. I have here two bulbs (Fig. 7), alike in shape and position of poles, the only difference being that one is at an exhaustion equal to a few millimetres of mercury—such a moderate exhaustion as will give the ordinary luminous phenomena—while the other is exhausted to about the millionth of an atmosphere. I will first connect the moderately exhausted bulb (A) with the induction-coil, and retaining the pole at one side (a) always negative, I will put the positive wire successively to the other poles with which the bulb is furnished. You see that as I change the position of the positive pole, the line of violet light joining the two poles changes, the electric current always choosing the shortest path between the two poles, and moving about the bulb as I alter the position of the wires.

This, then, is the kind of phenomenon we get in ordinary exhaus-

If, instead of a flat disk, a hemi-cylinder is used for the negative pole, the matter still radiates normal to its surface. The tube before you (Fig. 8) illustrates this property. It contains, as a negative pole, a hemi-cylinder (*a*) of polished aluminium. This is connected with a fine copper wire, *b*, ending at the platinum terminal, *c*. At the upper end of the tube is another terminal, *d*. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent the projection of the molecular rays to a focus is very beautifully shown. The rays of matter being driven from the hemi-cylinder in a direction normal to its surface, come to a focus and then diverge, tracing their path in brilliant green phosphorescence on the surface of the glass.

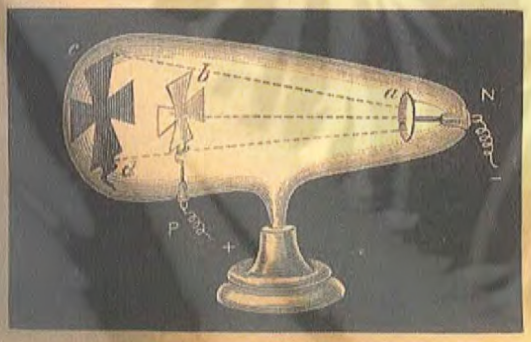
Fig. 8.



Instead of receiving the molecular rays on the glass, I will show you another tube in which the focus falls on a phosphorescent screen. See how brilliantly the lines of discharge shine out, and how intensely the focal point is illuminated, lighting up the table.

Radiant Matter when intercepted by Solid Matter casts a Shadow.—Radiant matter comes from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light, as would

Fig. 9.



be the case were the exhaustion less good. Where there is nothing in the way the rays strike the screen and produce phosphorescence, and where solid matter intervenes they are obstructed by it, and a shadow

ON RADIANT MATTER.*

By WILLIAM CROOKES, F. R. S.

II.

Radiant Matter exerts Strong Mechanical Action where it strikes.

WE have seen, from the sharpness of the molecular shadows, that radiant matter is arrested by solid matter placed in its path. If this solid body is easily moved, the impact of the molecules will reveal itself in strong mechanical action. Mr. Gimingham has constructed for me an ingenious piece of apparatus which, when placed in

Fig. 11.



the electric lantern, will render this mechanical action visible to all present. It consists of a highly-exhausted glass tube (Fig. 11), hav-

* A lecture delivered before the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879.

For these mechanical effects the exhaustion need not be so high as when phosphorescence is produced. The best pressure for this electrical radiometer is a little beyond that at which the dark space round the negative pole extends to the sides of the glass bulb. When the pressure is only a few millimetres of mercury, on passing the induction-current a halo of velvety violet light forms on the metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millimetre this dark space extends to the glass, and rotation commences. On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

Here is another piece of apparatus (Fig. 13) which illustrates the mechanical force of the radiant matter from the negative pole. A stem (*a*) carries a needle-point in which revolves a light mica fly (*b b*). The fly consists of four square vanes of thin, clear mica, supported on light aluminium arms, and in the center is a small glass cap, which rests on the needle-point. The vanes are inclined at an angle of 45° to the horizontal plane. Below the fly is a ring of fine platinum wire (*c c*), the ends of which pass through the glass at *d d*. An aluminium terminal (*e*) is sealed in at the top of the tube, and the whole is exhausted to a very high point.

By means of the electric lantern I project an image of the vanes on the screen. Wires from the induction-coil are attached, so that the platinum ring is made the negative pole, the aluminium wire (*e*) being positive. Instantly, owing to the projection of radiant matter from the platinum ring, the vanes rotate with extreme velocity. Thus far the apparatus has shown nothing more than the previous experiments have prepared us to expect; but observe what now happens. I disconnect the induction-coil altogether, and connect the two ends of the platinum wire with a small galvanic battery: this makes the ring *c c* red-hot, and under this influence you see that the vanes spin as fast as they did when the induction-coil was at work.

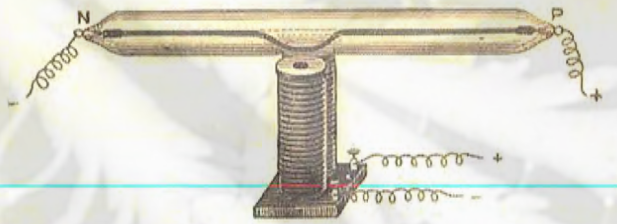
Here, then, is another most important fact. Radiant matter in these high vacua is not only excited by the negative pole of an induction-coil, but a hot wire will set it in motion with force sufficient to drive round the sloping vanes.

Radiant Matter is deflected by a Magnet.—I now pass to another property of radiant matter. This long glass tube (Fig. 14) is very highly exhausted; it has a negative pole at one end (*a*) and a long phosphorescent screen (*b*, *c*) down the center of the tube. In front of the negative pole is a plate of mica (*b*, *d*) with a hole (*e*) in it, and the result is, when I turn on the current, a line of phosphorescent light (*e*, *f*) is projected along the whole length of the tube. I now place beneath the tube a powerful horseshoe magnet: observe how the line of light (*e*, *g*) becomes curved under the magnetic influ-

flight from one end of the tube to the other. I heat the caustic potash with a spirit-lamp and so throw in a trace more gas. Instantly the stream of radiant matter responds. Its velocity is impeded, the magnetism has longer time on which to act on the individual molecules, the trajectory gets more and more curved, until, instead of shooting nearly to the end of the tube, my molecular bullets fall to the bottom before they have got more than half way.

It is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of radiant matter is the same as has been found to hold good at a lower vacuum. The experiments I have just shown you were with a very high vacuum. Here is a tube with a low vacuum (Fig. 16). When I turn on the induction-spark, it

FIG. 16



passes as a narrow line of violet light joining the two poles. Underneath I have a powerful electro-magnet. I make contact with the magnet, and the line of light dips in the center toward the magnet. I reverse the poles, and the line is driven up to the top of the tube. Notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises and pursues its path to the positive pole. In the high exhaustion, however, after the stream of radiant matter had dipped to the magnet it did not recover itself, but continued its path in the altered direction.

By means of this little wheel, skillfully constructed by Mr. Gimingham, I am able to show the magnetic deflection in the electric lantern. The apparatus is shown in this diagram (Fig. 17). The negative pole (*a*, *b*) is in the form of a very shallow cup. In front of the cup is a mica screen (*c*, *d*), wide enough to intercept the radiant matter coming from the negative pole. Behind this screen is a mica wheel (*e*, *f*) with a series of vanes, making a sort of paddle-wheel. So arranged, the molecular rays from the pole *a b* will be cut off from the wheel, and will not produce any movement. I now put a magnet, *g*, over the tube, so as to deflect the stream over or under the obstacle *c d*, and the result will be rapid motion in one or the other direction, according to the way the magnet is turned. I throw the image of the apparatus on the screen. The spiral lines painted on the wheel show which way it

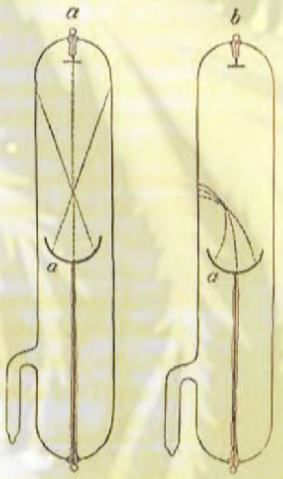
If the streams of radiant matter carry an electric current, they will act like two parallel conducting wires and attract one another; but if they are simply built up of negatively electrified molecules, they will repel each other.

I will first connect the upper negative pole (*a*) with the coil, and you see the ray shooting along the line *d, f*. I now bring the lower negative pole (*b*) into play, and another line (*e, h*) darts along the screen. But notice the way the first line behaves: it jumps up from its first position, *d f*, to *d g*, showing that it is repelled, and if time permitted I could show you that the lower ray is also deflected from its normal direction: therefore the two parallel streams of radiant matter exert mutual repulsion, acting not like current carriers, but merely as similarly electrified bodies.

Radiant Matter produces Heat when its Motion is arrested.—During these experiments another property of radiant matter has made itself evident, although I have not yet drawn attention to it. The glass gets very warm where the green phosphorescence is strongest. The molecular focus on the tube, which we saw earlier in the evening (Fig. 8), is intensely hot, and I have prepared an apparatus by which this heat at the focus can be rendered apparent to all present.

I have here a small tube (Fig. 19, *a*) with a cup-shaped negative pole. This cup projects the rays to a focus in the middle of the tube. At the side of the tube is a small electro-magnet, which I can set in action by touching a key, and the focus is then drawn to the side of the glass tube (Fig. 19, *b*.) To show the first action of the heat, I have coated the tube with wax. I will put the apparatus in front of the electric lantern (Fig. 20, *d*), and throw a magnified image of the tube on the screen. The coil is now at work, and the focus of molecular rays is projected along the tube. I turn the magnetism on, and draw the focus to the side of the glass. The first thing you see is a small circular patch melted in the coating of wax. The glass soon begins to disintegrate, and cracks are shooting starwise from the center of heat. The glass is softening. Now the atmospheric pressure forces it in, and now it melts. A hole (*e*) is perforated in the middle, the air rushes in, and the experiment is at an end.

FIG. 19.



I can render this focal heat more evident if I allow it to play on a piece of metal. This bulb (Fig. 21) is furnished with a negative pole in the form of a cup (*a*). The rays will therefore be projected to a focus on a piece of iridio platinum (*b*) supported in the center of the bulb.

the metal is now white-hot. I increase the intensity of the spark. The iridio-platinum glows with almost insupportable brilliancy, and at last melts.

The Chemistry of Radiant Matter.— As might be expected, the chemical distinctions between one kind of radiant matter and another at these high exhaustions are difficult to recognize. The physical properties I have been elucidating seem to be common to all matter at this low density. Whether the gas originally under experiment be hydrogen, carbonic acid, or atmospheric air, the phenomena of phosphorescence, shadows, magnetic deflection, etc., are identical, only they commence at different pressures. Other facts, however, show that at this low density the molecules retain their chemical characteristics. Thus by introducing into the tubes appropriate absorbents of residual gas, I can see that chemical attraction goes on long after the attenuation has reached the best stage for showing the phenomena now under illustration, and I am able by this means to carry the exhaustion to much higher degrees than I can get by mere pumping. Working with aqueous vapor, I can use phosphoric anhydride as an absorbent; with carbonic acid, potash; with hydrogen, palladium; and with oxygen, carbon, and then potash. The highest vacuum I have yet succeeded in obtaining has been the $\frac{1}{20,000,000}$ of an atmosphere, a degree which may be better understood if I say that it corresponds to about the hundredth of an inch in a barometric column three miles high.

FIG. 21.



It may be objected that it is hardly consistent to attach primary importance to the presence of *matter*, when I have taken extraordinary pains to remove as much matter as possible from these bulbs and these tubes, and have succeeded so far as to leave only about the one millionth of an atmosphere in them. At its ordinary pressure the atmosphere is not very dense, and its recognition as a constituent of the world of matter is quite a modern notion. It would seem that, when divided by a million, so little matter will necessarily be left that we may justifiably neglect the trifling residue, and apply the term *vacuum* to space from which the air has been so nearly removed. To do so, however, would be a great error, attributable to our limited faculties being unable to grasp high numbers. It is generally taken for granted that when a number is divided by a million the quotient must neces-

fore you leave this room? The hole being unaltered in size, the number of molecules undiminished, this apparent paradox can only be explained by again supposing the size of the molecules to be diminished almost infinitely—so that, instead of entering at the rate of one hundred millions every second, they troop in at a rate of something like three hundred trillions a second! I have done the sum, but figures when they mount so high cease to have any meaning, and such calculations are as futile as trying to count the drops in the ocean.

In studying this fourth state of matter we seem, at length, to have within our grasp and obedient to our control the little indivisible particles which, with good warrant, are supposed to constitute the physical basis of the universe. We have seen that, in some of its properties, radiant matter is as material as this table, while in other properties it almost assumes the character of radiant energy. We have actually touched the border-land where matter and force seem to merge into one another, the shadowy realm between known and unknown, which for me has always had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this border-land, and even beyond; here, it seems to me, lie ultimate realities, subtile, far-reaching, wonderful.

"Yet all these were, when no man did them know,
Yet have from wisest ages hidden beene;
And later times thinges more unknowne shall show.
Why then should witlesse man so much misweene,
That nothing is, but that which he hath seene?"

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I am now in my eightieth year and still taking patients. our rent has been raised and we will be compelled to move if we can find a cheaper place. I shall hate it as we have been here for thirteen years and it had grown to seem like home. My five meter ultra short wave(which I call my "VITAL N RMALIZER) Do you know anyone with High Blood-pressure.Thirty two years ago I was running a systolic of over Two hundred. The Met. Life Co rates High Blood pressure as PUBLIC ENEMY NO1 it kills 600,000 annually (more than Cancer and tuberculosis combined I am now running a norm l pressure of about 135 and am feeling very well dispite my age. Are you still doing ELECTRICKS? I have all my tesla apparatus and dont know what to do with it. Do you know anyone who would take it off my hands. We are sadly in need of money and I would sell all my H-F apparatus for fifty dollars. You have no doubt seen the million volt coil which I gave to the Planetarium. Can you not come up and look over my High-frequency "JUNK-PILE". Today Jose Iturbe came in and played for us. He is going to try to sell my piano forme He says "IT IS A VERY GOOD PIANO" I also want to sell my harp We shallbe very glad to see you again. If this reaches you please call me up

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McIntosh Galvanic Wave Uni-Directional - the equivalent is obtained on the Model "J" by placing your dials on 2 and 0.

McIntosh Galvanic Wave Smooth - the equivalent is obtained on the Model "J" by placing your dials on 4 and 1.

Galvanic Wave Rough - This appears to be a rectified AC current, but unfiltered. We do not have this current on our machine.

320 cycle Sinusoidal - the equivalent is obtained on the Model "J" by placing your dials on 2 and 1.

320 cycle Sinusoidal Wave - The equivalent is obtained by placing the dials on the Model "J" on 4 and 2.

If we can be of further service advise us.

Cordially yours,

H. G. FISCHER & CO.

P. P. Muskat
Vice-President.

PPM:FZ.



H. G. FISCHER & Co.

MANUFACTURERS

X-RAY AND ELECTRO SURGICAL MEDICAL EQUIPMENT

GENERAL OFFICE 2323-2345 WABANSIA AVE.

CHICAGO 47, ILL.

REPRESENTATIVES IN ALL PRINCIPAL CITIES AND FOREIGN COUNTRIES

CABLE ADDRESS "FISCHERCO" TELEPHONE ARMITAGE 0321

September 23, 1946

F. J. Moennighoff, M.D.
Monett, Missouri

Dear Dr. Moennighoff:

It has just been discovered, Dr. Moenninghoff, that we failed to send you the technic chart and the instructions for the operation and maintenance of your model "J" galvanic and contractile currents generator. We believe that the enclosed instructions will be of assistance to you.

You had asked if we have a service man in your territory. Yes, we do. Mr. G. H. Richardson, 405 South McGuire, Warrensburg, Missouri represents us in your territory.

Yours very truly,

H. G. FISCHER & CO.

M. A. White

MAW:pwr



H. G. FISCHER & Co.

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X-RAY AND ELECTRO SURGICAL MEDICAL EQUIPMENT

GENERAL OFFICE 2323-2345 WABANSIA AVE.

CHICAGO

REPRESENTATIVES IN ALL PRINCIPAL CITIES AND FOREIGN COUNTRIES

CABLE ADDRESS "FISCHERCO" TELEPHONE ARMITAGE 0322

February 20, 1941

Dear Doctor:

We are very happy to enclose with this letter another group of abstracts covering the uses of galvanic and contractile currents.

It is our purpose to provide these abstracts, for our friends and customers, as new reports and articles appear in the medical press. We shall appreciate any comments you care to make.

Sincerely yours,

H. G. FISCHER & COMPANY

H T Fischer

Vice President

HTF:MW



H. G. FISCHER & Co.

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CABLE ADDRESS
"FISCHERCO"
TELEPHONES
FRANKLIN PARK,
GLADSTONE 5-0612
CHICAGO,
TUXEDO 9-0400

February 6, 1951

J. Paul Spanogle, D. O.
43 Lincoln Way, W.
Chambersburg, Pennsylvania

Dear Doctor Spanogle:

Thank you for your recent request for a copy of our Manual of Simplified X-ray Technic.

We are pleased to send you herewith a copy of our Manual and we hope you will find it to be of some interest and value to you in your work.

If we may be of any further service to you at any time please do not hesitate to call upon us.

Cordially yours,

H. G. FISCHER & CO.

K. W. Miller

Field Service Department

KDM:bc
enc.



12-9-11

Hi Jeff.

Here is the letter I promised to send you. I sure enjoyed our talk yesterday on the phone.

Please let me know if you learn anything about H. G. Fischer & Co.'s role in World War II.

Thanks!

Happy Holidays,

Jim Kerr

PO Box 5
Brooksville FL 34605-0005
Cell Phone 352-238-6226

OFFICE OF
SMITH & WESSON,
REVOLVER Manufacturers

Springfield Mass November 28, 2011

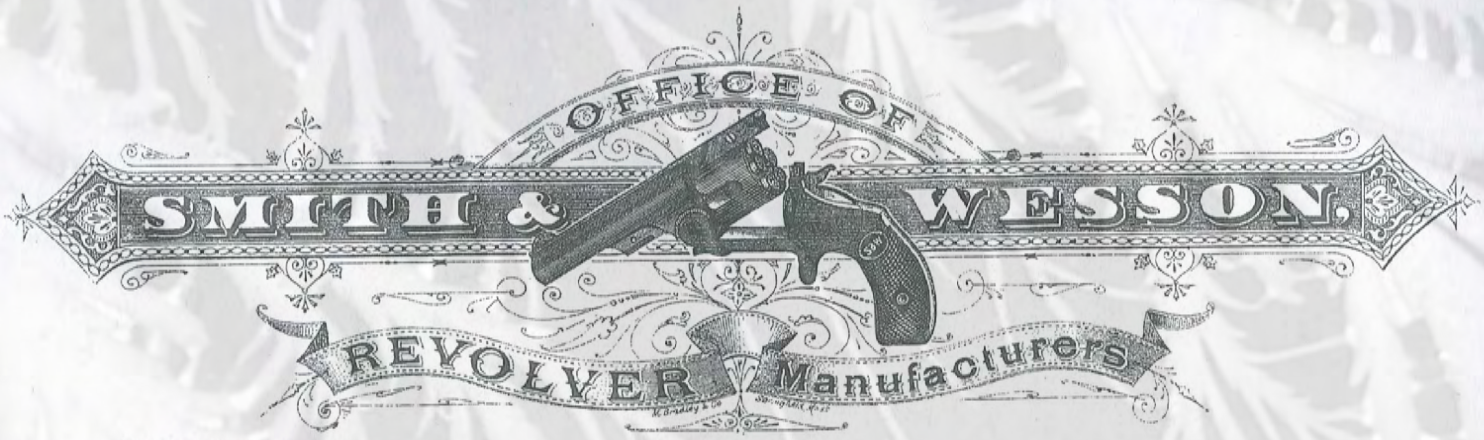
The revolver described in your recent letter is the .38 Victory Model. This model was introduced in 1942 and manufactured until 1945. Total production was 850,000 units. It was produced in barrel lengths of 2", 4" and 5", in both .38 Special and .38 S&W calibers.

The Victory Model was supplied to all branches of the U. S. Armed Services in the .38 Special caliber. Guns produced for England, Canada, and other allies were chambered for the .38 S&W cartridge and were supplied under the Lend Lease Program. These revolvers since they were on loan to the Allied Forces were United States property and so marked on the revolvers.

A small group of the Victory Models was sold to commercial companies and Police Agencies during the war time production. The orders for commercial sales were submitted to the United States Governments Defense Supply Corporation which would then issue sales orders to Smith & Wesson directing them to sell to the various listed companies. The Defense Supply Corporation ordered revolvers were shipped without U.S. or other military markings.

Production of this model with the prefix V began on January 1, 1942, and continued through V750,000. All firearms produced after this carry the prefix SV which signifies the installation of a new hammer block.
Generally, the Victory Model was finished in a rough military finish. A limited quantity in this finish was sold to private firms for security use. These firearms were void of military markings and were released only under government orders.





We have researched your Smith & Wesson .38 Victory Model, United States Defense Supply Corporation Contract, Commercial Sales Variation, caliber .38 S&W Special, revolver in company records which indicate that your handgun, with serial number V58685 was shipped from our factory on August 4, 1942, and delivered to H. G. Frischer & Co., Chicago, IL. The records indicate that this revolver was shipped with a 4 inch barrel, military midnight black finish, butt swivel, and smooth walnut grips.

We trust that the information furnished will be helpful and of interest.

Sincerely,
SMITH & WESSON

Roy G. Jinks
Historian

1507 Jobe Ave.
St. Charles, IL 60174

Dec. 13, 2007
Cell- 630-229-7777

Mr. Jeff Bethany
627 36th St.
West Palm Beach, FL 33407

Dear Jeff,

As before, a pleasure talking to ya!

The books (copies) look fairly close to the original
I had copied and are identical — one for
ya personally and one for the museum or
however ya see fit! I bet ya'll get the
look out of looking through them I did.
Where my dad had the orig. I have no idea.
But it popped up as the home was cleaned out
very recently. And it had a colored paper
w/ title "Pruritus Ani Et Vulvae" stuck
in the front loosely. So I duplicated it too!
So loosely stuck in your 2 copies of (over)

the book are two copies of it (you'll see it's
from the same era from which fact I assume
it was put in there about the time
the book was created in 1926 for whatever reason).

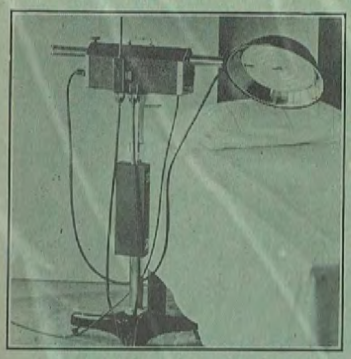
When you are able to date the tube close
sent here and figure out what it is for
if that's possible — drop me a note. Like the
books, it's yours now, hopefully a worthwhile addition
for your museum.

Hannah lent me the copy you gave her of Catalog
No. 14 from Jan. '24. Pages 88 + 89 I found
missing when duplicating for my bookshelf. If your
copy has those pages and you could copy them
and send them up to me, I will get them
into my and into Hannah's copies and return Hannah's
to her complete. Thanks!!

Best —

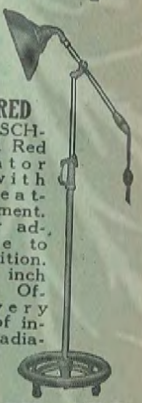
Jonathan

ULTRA-VIOLET . . . INFRA RED . . . CARBON ARC Lamps



MERCURY QUARTZ

FISCHER "Cold" Mercury Arc Lamps are available in two basic types — for general and for orificial irradiation. Character of radiation same in both types. All lamps have precision control, enabling operator to deliver rays at low, medium or high intensity. A very important characteristic of these lamps is the intensity of the rays at about 2536A. For general use, the FISCHER Combination Lamp (No. 3980), equipped with both grid type and orificial type burners, is recommended. Other models available.



INFRA RED

This FISCHER Infra Red Generator made with singly heating element. Easily adjustable to any position. Eleven - inch reflector. Offers every service of infra red radiation.

CARBON ARC

The FISCHER Model "O" Twin Carbon Arc Lamp delivers as much ultra violet, visible, and infra red radiation as any carbon arc lamp on the market, operating on a regular lighting circuit. Operates equally well on direct or alternating current. Localizing cones available when desired.

Sign and Mail This Card Today

Please send full information — no obligation — regarding the lamp I have checked below.

- ☐ FISCHER "Cold" Mercury Arc Lamp
- ☐ FISCHER Infra Red Generator
- ☐ FISCHER Model "O" Carbon Arc Lamp

Name.....

Address.....

Form 1601 Printed in U.S.A.

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FEATURES

Illustration above shows unit mounted on mobile base and lead-lined cabinet (for film protection). Cables metal protected and always out of way. Tube inclosed in metal case. Control very fine.—two meters with separate controls — synchrotimer accurate to 1/60 second — remote control switch. Finish black and chromium or ivory and chromium. Arrangement with counterbalance, with table available when desired.

FISCHER Model "DSP-20"

Superior in Power — Positively Shockproof — Very Compact — Radiography — Also Fluoroscopy — and Marvelously Simple to Operate.

For making radiographic diagnosis — in such cases as fractures, foreign bodies, pathology of heart, lungs, stomach, colon, sinuses, treatment of superficial skin lesions, and so on — and for fluoroscopy, this new MODEL "DSP-20" is easily the outstanding unit in its field. It delivers 20 M.A. at 67 K.V.P.

SUPERB PERFORMANCE

Superb chest negatives can be made in 1/10 to 1/5 second. A knee or shoulder in ½ second. Stomach or colon in ½ to ¾ seconds. Completely flexible — usable with table and Bucky or without — finest quality materials and workmanship. One x-ray specialist called this unit a "performing fool." In portable or semi-portable X-ray apparatus, you will find this unit unexcelled in power, flexibility, simplicity and efficiency. Both milliamperage and kilovoltage variable.



Mail this card. No physician today need be without X-ray facilities.

SIGN AND MAIL THIS CARD TODAY

Please send immediately, by return mail, descriptive folder on the latest model FISCHER "DSP-20" Shockproof X-ray Unit. No obligation.

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Address.....

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Fischer MODEL "CSWI" COMBINATION CABINET

Combines in one cabinet — short wave, galvanic current, desiccation, cautery, diagnostic circuit, suction, suction-vibration, pressure, pressure-vibration. Designed for eye, ear, nose and throat specialists, also for all physicians desiring these facilities.

The short wave unit in this cabinet is the well-known FISCHER Model "SWI-12", affording all short wave applications, including inductance cable. The other facilities, galvanism, desiccation and so on, are independently produced and in every way as efficient as when housed in separate cabinets.

GUARANTEED PERFORMANCE

Satisfactory performance is guaranteed. Special features are: A perfectly smooth galvanic current; desiccation current, high voltage, low milliamperage; cautery current without jumps; diagnostic circuit sufficient for all diagnostic purposes; suction and pressure changes to vibration simply by throwing respective switches. Copper tubing is used inside cabinet instead of unstable rubber tubing.

LIST OF ACCESSORIES INCLUDED

One complete set of accessories, required for using the various facilities of the Combination Cabinet.

• Full information sent without obligation. Simply sign and mail this card.

SIGN AND MAIL THIS CARD TODAY

Please send full information regarding your Model "CSWI" Combination Cabinet. No obligation.

Name.....

Address.....

Form 1603

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CHICAGO, ILL.

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H. G. FISCHER & COMPANY

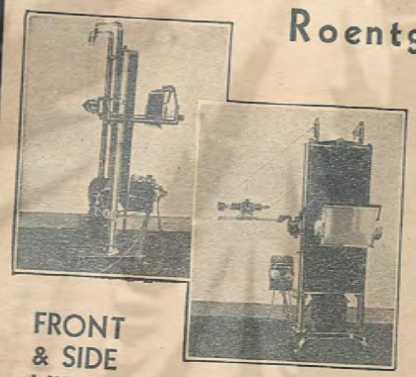
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ALL roentgenographic and fluoroscopic work can be performed with the finest detail. This new outfit is built on Fischer experience and is fully worthy of the Fischer reputation. A more efficient, handy, serviceable unit cannot be had at any price. Compact, durable, safe, ready to operate. All installations made by factory-trained representatives.

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Our claim and our guarantee is that this unit will equal in performance any other similar combination, regardless of price, and it will exceed many. Every modern electrical and mechanical development is built into it. Send for full information.

PRICE ONLY $995

Fashioned completely of metal with panel of bakelite. Screen moves freely to any position. Excellent mobility. Floor locks. Finish, natural polished aluminum, heavy nickel plate or rich black enamel. **An Unequalled Value at $995.00.**

FORM 12:6

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Please send me full information regarding your new Roentgenographic and fluoroscopic unit. No obligation.

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